CR 115380

OFFICE OF PRIME RESPONSIBILITY

FS5

N72-18983

OPEN

(NASA-CR-115380) NATIONAL AERONAUTICS AND SPACE ADMINISTRATION MANNED SPACECRAFT CENTER DATA BASE REQUIREMENTS STUDY Final Report (Computer Sciences Corp.) 30 Jul. 1971 101 p CSCL 05B G3/34

Unclas 17652

COMPUTER SCIENCES CORPORATION

CSC

FINAL REPORT

FOR THE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION MANNED SPACECRAFT CENTER DATA BASE REQUIREMENTS STUDY

TYPE 1 DOCUMENTATION
PRELIMINARY – NASA APPROVAL PENDING

Prepared For

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
Houston, Texas

Contract No. NAS9-10995

July 30, 1971

COMPUTER SCIENCES CORPORATION

8300 S. Whitesburg Drive

Huntsville, Alabama 35802

Major Offices and Facilities Throughout the World

CSC

FOREWORD

This study was administered in the Flight Software Branch, Flight Support Division, MSC with B. L. Brady assigned as Technical Monitor. Through careful planning and coordination, Mr. Brady, assisted by Mrs. Shirley Hinson, added significantly to our insight into and understanding of related MSC functions and organizations and, thereby, the accuracy of the study reported herein.

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

LIST OF ILLUSTRATIONS

LIST OF TABLES

CSC

SECTION 1 - INTRODUCTION

SECTION 1 - INTRODUCTION

During the course of this study Computer Sciences Corporation (CSC) evaluated the types of data that the Manned Spacecraft Center (MSC) should automate in order to make available essential management and technical information to support MSC's various functions and missions. Also, the software and hardware capabilities to best handle the storage and retrieval of this data were analyzed.

MSC's requirements for new types of high volume data continue to grow, and the need to review and manipulate this data on a "more data faster" basis increases. It has become evident that a number of necessary applications to support these requirements have not yet been automated and that others are less efficient than desired.

In existing systems, a large percentage of the total time and manpower available is spent in maintaining the data base and printing routine reports. When a user recognizes a need for accurate, up-to-date information in a usable form, he must take a number of steps to "get the problem onto the computer." Several days, weeks, or months later, the original poser of the problem is presented a report. Unfortunately, in many cases this report may contain too much or too little information for his purposes; in the meantime, his problem may have changed, or the response may have been received too late for the user to take effective action.

Analysis at MSC discloses that many of the desirable features required to manage a large data base can be found in embryonic form in several computer complexes within the Center. It is clear, however, that they have not been brought together to form a single powerful data management tool.

A properly implemented Data Management Supervisor (DMS) would permit the user or programmer to quickly describe entries in a data base, to load them into the machine, to ask questions about them, to have the data displayed on a Cathode Ray Tube (CRT), to obtain hard copy reports, and to update and maintain the data base. All of these functions could be performed either on a production basis or interactively from a terminal in an on-line time-sharing mode.

The following report develops CSC's recommendations for a unified data base and a DMS that provides a cost effective solution to MSC's data automation requirements. The recommendations presented are projected through a time frame that includes the Earth Orbit Space Station. The recommendations are based on a detailed requirements analysis, employing data acquired through structured interviews of a wide sample of MSC personnel, and on in-depth studies and evaluations of existing and/or feasible data management systems.

CSC

SECTION 2 - PILOT STUDY ACCOMPLISHMENTS

SECTION 2 - PILOT STUDY ACCOMPLISHMENTS

2.1 GENERAL

In order to properly manage a complex set of missions such as those in the integrated manned space flight plan, availability of extensive technical and management information will be required. It is essential that this data be current and easily accessible to both project management and technical personnel for pre-mission planning, mission support, and post-flight analysis.

In the past, most of this data was compiled and handled manually. Because of the relatively large number of vehicles and frequent flights envisioned for future programs, an automated information management system is necessary. Such automation will effect a more efficient operation and result in reduction of costs in the areas of program management, mission planning, and support operations.

CSC was selected by MSC to perform the analysis of MSC data base requirements and interests. It was necessary to conduct a study to determine the types of data that require automation and to determine the system that can best handle the storage and retrieval of this information. From the information obtained by this analysis, a detailed description and structure have been developed of the software capabilities and data base that must be provided by the MSC future DMS.

The first step in the study was to conduct personal interviews with MSC personnel. These interviews acquainted the various MSC groups with the goals and purposes of the study and extracted the data processing needs of the various groups. These interviews also provided opportunities to discuss with these users the capabilities of a DMS.

Utilizing the information gleaned from the interviews, an analysis of MSC data requirements was made. A list of candidate and recommended application data files to be structured into the pilot DMS data base was compiled and presented the MSC technical monitors with a report on the capabilities MSC personnel wanted to see in the pilot DMS. Most of the selected application data files were stored in Univac 1108 data format and had to be converted to IBM 360 data format before they could be structured into the data base. Data conversion programs for these files were written.

The NIPS and HYPERTEXT systems were chosed for the pilot DMS. A detailed analysis was performed of these two systems to determine the best possible means of demonstrating DMS capabilities through them. Several terminal user queries were prepared for each application data file.

Demonstration of the pilot DMS was the next major step in the study. The various MSC groups were invited to view the pilot DMS and give their comments. Personal terminal console training was given to several individuals, thereby enabling them to utilize the two systems.

Throughout the project, in-depth analyses were made of many generalized DMS's currently operating in the data processing industry. Several demonstrations of new hardware and software in the data processing industry were given by various manufacturers. These efforts were expended to ensure that the study incorporated the latest in the data processing technology.

The information gathered throughout the study is organized into this final report to elucidate the requirements and additional desirable capabilities of a Center-wide DMS and data base at MSC.

2.2 SUMMARY OF INTERVIEWS

During the data base requirements study project, CSC contacted more than 200 people throughout MSC in order to inform them that a data base requirements study was taking place and to determine their interests in participating in the study. Many people in virtually all directorates were interested in participating in the data base requirements study. Personal interviews were scheduled with each interested MSC group. A list of MSC personnel who were interviewed is contained in Appendix A.

It was recognized that most of the people at MSC who would be major users of a DMS were not technically oriented. They were not familiar with many of the functional capabilities that can be provided by a DMS. Hence, a list of questions was prepared to be used in the interviews. A list of these questions is contained in Appendix B. These questions were designed to extract the needs of each MSC group while at the same time acquaint them with the various capabilities of a DMS. During the interviews, CSC analysts explained the many capabilities of a DMS. Each MSC group representative then stated whether or not their area required such a capability. Some problems unique to the individual MSC groups were also discussed in these meetings. Different ways that a DMS could help solve these problems were presented to the people being interviewed. Through this method the people who were interviewed were able to expand their concepts of how to make a computer more functional in their sphere of activity.

The interviews produced considerable information including the requirements that each group has for a DMS and the capabilities they wanted to see in a DMS. A comprehensive report of the requirements for the pilot DMS was then prepared. This report was designed to aid the MSC technical monitors in the selection of the pilot DMS.

Another accomplishment of the interviews was the identification of a cross-section of MSC groups that would supply data for the pilot DMS data base. Sample data was extracted from these files and structured into the data base.

2.3 PILOT DMS SYSTEMS SUMMARY

A list of currently operational DMS's that were available at no cost to MSC was given to the implementing contractor on August 10, 1970. This list of candidate systems contained three actual DMS systems and three textual data processor systems as follows:

- Data Management Systems

  NIPS
  USABAAR DMS
  INQUIRY

- Textual Processor Systems

  HYPERTEXT
  TEXT360
  ATS/360

A brief description of each of these systems is given below:

- NIPS. The National Military Command System (NMCS) Support Center System/360 Formatted File System was developed for the NMCS by IBM Federal Systems Division. IBM 360 NIPS/FFS evolved from the IBM 1410 NIPS and can be traced back to the 1959 438L system for the IBM 709 and 704 computers. NIPS utilizes some older second generation software techniques.

- USABAAR DMS. The United States Army Board of Aviation Accident Research (USABAAR) Data Management System (DMS) is currently being used on an IBM 360 at Fort Rucker, Alabama, to maintain, retrieve, and display records of Army aviation accidents. USABAAR DMS was developed for the Army by Computer Sciences Corporation (CSC). The system is derived from COGENT III, a very powerful and highly advanced data management system developed by CSC. USABAAR DMS utilizes the latest state-of-the-art third generation software and hardware capabilities.

- INQUIRY. The INQUIRY System was developed by the Federal Systems Division of IBM for the NASA Automatic Data Processing Division, Kennedy Space Center. This new INQUIRY System was modeled after the INQUIRY System of the Saturn Information Reporting System (SIRS) which was used by IBM for support of their contracts at Cape Kennedy.

- HYPERTEXT. The development of HYPERTEXT was supported in part by a contract between Brown University and IBM. It is a general purpose text handling and editing system for use by writers, editors, and on-line readers. It takes advantage of the full capabilities of a sophisticated display terminal, the IBM 2250. The user controls the system by pressing keys on a functional keyboard, by pointing at the text with a light pen, and by entering text via the alphanumeric keyboard. The output portion of HYPERTEXT is actually a translator which transforms all of the text into a linear string of characters recognizable by the TEXT 360 programs.

- <u>TEXT 360</u>. TEXT360 is a text processing system with data updating, and page formatting capabilities. It was originally developed by IBM to be used to produce the reference documents of the System Reference Library (SRL). TEXT360 is operated in the batch mode. Input to the system is on free form punched cards. Output is camera-ready and is produced on a high-speed printer. TEXT360 updating capabilities permit the insertion, deletion, and replacement of characters, words, lines, and groups of lines. In addition, blocks of text may be moved from one place to another in a document. TEXT360's formatting capabilities permit either one-column or two-column pages. Routine functions include hyphenation, line justification, column headings, and indentions. More complex functions include the generation of horizontal and/or vertical lines for tables or figures.

- <u>ATS/360</u>. The Administrative Terminal System, ATS/360 is a real-time system that is used for data entry and text processing applications. ATS/360 has a comprehensive set of text processing and manipulating features. Data entry is from any OS data set or from a remote terminal device such as the IBM 2741 Communications Terminal.

In order to present the most productive demonstrations possible, CSC compiled a report entitled "Desirable Capabilities of the Pilot Data Management System for the MSC Data Base October 1, 1970." In this report factual criteria, based on CSC's own experience in the area of DMS's and the requirements of MSC management, were presented to the contract monitors to aid them in their selection of the pilot DMS. As supporting documentation for this report, a DMS capability matrix which summarized the results of the personal interviews was also presented at that time.

MSC established user requirements as the prime consideration in the selection of the pilot DMS. Other major considerations included cost, compatibility with other system hardware, and terminal capabilities. Trade-offs were made to approach a degree of satisfaction of all requirements. These trade-offs generally considered expediency of implementation of the DMS. As a result of these trade-offs, the NIPS and HYPERTEXT systems were selected by MSC to be used in the pilot study.

On November 2, 1970, the implementing contractor presented to MSC the results of its analysis of the candidate systems in the document "Program Evaluation Report." Based on the implementing contractor's recommendations, MSC selected the NIPS and HYPERTEXT systems to comprise the pilot DMS. CSC analysts performed a two phased analysis and evaluation of the pilot DMS systems.

The first phase occurred prior to the actual implementation of the systems and consisted of an in-depth study of all available documentation on the two systems. This study was oriented toward the accomplishment of three objectives: the familiarization of all options and procedures necessary to the physical operation of the two systems, obtaining detailed knowledge of the capabilities provided by the systems, and discovery of possible problem

areas which could impact the demonstrations. These three objectives were accomplished within the time frame preceding the pilot system implementation and allowed CSC to proceed directly to the second phase of the analysis and evaluation as soon as the systems were operational.

The second phase was a planned, hands-on checkout of all the operational functions supported by the DMS's. The objectives were to develop the analysts' proficiency in operating the systems and to discover any idiosyncrasies of the systems that had not been uncovered during the documentation study. This analysis was documented in two special reports, "Pilot DMS Problem Areas Analysis" and "NIPS Demonstrable DMS Capabilities."

The first report identified some of the major problems encountered and offered solutions to those which could be most readily corrected. The second report compared capabilities that were operational as of February, 1971, as opposed to those required to adequately demonstrate the power of the DMS concept desired by MSC personnel.

2.4 PILOT DMS DATA

The data base requirements study questionnaire and personal interviews established a benchmark to be used in the selection of the users and data for the pilot data management system. The basic criteria for the selection, gauged by the benchmark of both users and data, was that they be representative of a good cross-section of users and data types at MSC. A second consideration was the ease of data implementation and what features of the pilot system could be demonstrated with it.

The major portion of this task involved the gathering of the information required to establish a valid benchmark. A report was compiled, based on the findings of the personal interviews and CSC's past experience, entitled "Candidate Data Files and Recommended Data Files for the MSC Data Base, October 6, 1970."

The following MSC user application data files were selected for inclusion into the pilot DMS data base:

- Labor Distribution
- Accounting
- Procurement 497
- RMD
- Contract Status Report
- Budgetary Control
- Capitalized Equipment
- Engineering Standards Information
- Earth Resources Text and Table Files
- Flight Control Manpower Status
- Skylab Program Operational Data Book
- Statements of Work
- Graphic Arts

- Catalog Index
- Lunar Sample Natural Language Information
- Astronaut and Clinical Patients Record
- Advanced Spacecraft Cost Analysis

The first ten data files were implemented into the data base for utilization by the NIPS system. The Skylab Program Operational Data Book and Statements of Work files were implemented for utilization by HYPERTEXT. Seven conversion programs were written to convert the MSC application data in seven of the above files to IBM 360 data format for the implementing contractor. These data conversion activities are described in Appendix G.

2.5 PILOT DMS DEMONSTRATIONS

The personal interviews revealed that the majority of MSC groups have similar data requirements that necessitate access to a Center-wide data base. In order for the MSC groups to fully appreciate the power of a DMS, it was necessary for them to see one in action.

Utilizing past experience in the commercial and technical data areas, demonstrations of the NIPS and HYPERTEXT systems were designed to enlighten MSC managers as to the capabilities offered by a DMS. Actual MSC data was used to prepare program queries for a representative cross-section of activities. By doing this, the demonstrations were made meaningful to the viewers and helped them to relate their data requirements to what a DMS could do for them.

The demonstrations showed how data could be retrieved from the data base, sorted, updated and displayed to a user. Many questions were asked at the demonstrations and factual answers were given to all of them. In many instances, a query at the terminal was prepared to implement a viewer's question to demonstrate how a DMS could immediately be invoked to solve his problem. These demonstrations induced much interest and expanded the concept of a DMS for attendees. A list of the pilot DMS demonstrations is given in Appendix C.

NIPS and HYPERTEXT were not intended to be used as production systems, but the terminal needs of some MSC groups were so great that some production use of the systems was allowed. It was recognized that the earth resources area could utilize the NIPS system on an interim basis to assist in their data queries. Upon request, the complete earth resources data file was structured into the pilot DMS data base. This was done and some queries of their data were shortened by as much as three weeks. Also a number of people actually entered production documents into the data base and formatted them using the HYPERTEXT system.

It was made evident that the needs of each MSC group are unique in many respects. No generalized DMS can completely satisfy all of these unique needs, but experts who are experienced in DMS development can modify a general system to meet specific needs.

One of the most important parts of a DMS is the data base. Each data area requires a unique structure to make it most efficient for data queries. An analysis of each data area must be made by people experienced in data structuring techniques.

2.6 CONCLUSIONS

During the conduct of the study several conclusions became apparent. First of all, the availability of data to the users on a timely basis was of prime importance. This requirement presented itself in a number of different forms. Timeliness, availability, and the capability to selectively and randomly review data was high in each user's considerations.

Also, a large number of users are developing or considering independent solutions to this problem because of the lack of an integrated data base management system at MSC. Firm procedures will be required to prevent a proliferation of independent systems involving inefficiency and duplication of effort.

Finally, the pilot DMS was effective in demonstrating that most of these information and data problems can be solved by an effective DMS. As a result of the interviews and demonstrations, a comprehensive list of required capabilities necessary to support users and desirable capabilities to further enhance retrieval and display effectiveness has been compiled.

CSC

SECTION 3 - SYSTEM REQUIREMENTS

SECTION 3 - SYSTEM REQUIREMENTS

3.1 FUTURE SYSTEM OVERVIEW

Two categories of capabilities have been defined to support the many users' requirements that were identified during the course of the study. First, required capabilities are those functions that are necessary to support the user by creating a data base, maintaining the data base, and providing optional methods for processing and retrieving information. Second, desirable capabilities are additional functions which further enhance the practicality of the total system by orienting it more to the individual user and the solution of his problems.

Both categories of capabilities were derived through the process of interviewing a cross-section of MSC users and then demonstrating the effects of these capabilities to them on the pilot system.

The nature of MSC's data and the effect of the Skylab and Space Shuttle programs on that data are the dominant factors to be considered in the design of the MSC data base and DMS. MSC needs a DMS that will handle the data explosion that is going to occur as a result of the Skylab and Space Shuttle programs. These programs will be in operation through 1975. The DMS should be installed as soon as possible to ensure that the system will be productive before the Skylab experiments begin.

Most of MSC's currently active data files are basically static in nature. The data content changes, but the volume normally does not expand significantly. For instance, the personnel data file will only expand as new employees are hired. The number of records on the file is static in the sense that the number of employees does not fluctuate appreciably. The same is true of the payroll file.

Much of the data produced from the Skylab experiments will be environmental data and will be in demand by many segments of the general public. This data will be dynamic (constantly growing in size) and will require large storage capacity and direct access structuring techniques. A thorough analysis of the data to be structured into the data base and the structuring techniques to be used must be made by personnel familiar with data base construction.

A properly designed DMS would supply the data processing needs of MSC well past 1975. Such a system is discussed in detail throughout the remainder of this report.

3.2 REQUIRED DMS FUNCTIONAL CAPABILITIES

There are certain basic capabilities which must be provided by the DMS. The following paragraphs describe those features which are considered essential to successful operation of such a system at MSC.

- Terminal and Batch Processing. At the present time, the vast majority of MSC computer applications are run in the batch mode. Terminal capability is provided on an extremely limited basis to a few MSC groups. A DMS provides both batch and terminal processing capabilities. Terminal processing involves accessing of the data base from either a local (hard wired) or remote (common carrier line) terminal. It involves the real-time processing of many terminal users' requests during the same time period by using the computer's time-sharing capability. Batch processing involves data that has been collected over a period of time and is then processed by the computer. Applications which do not require a quick answer or which process a large amount of input data are normally done in the batch mode. Applications which require quick answers will be accomplished using queries in the terminal mode.

- Data Base Description. A DMS is useless without an effective, well structured data base. Some means of describing data in the data base must be provided. This is accomplished by a data description language. The language will describe such things as field name, field length, record key, record length, file name, file structure type, data security, data type, etc. This is normally the first step in the implementation of a DMS. Once the module to describe the data base is written and installed, data files can be structured into it.

- Data Access Security. Securing data at various levels is mandatory for MSC. Update restrictions are necessary to prevent unauthorized altering of data. Thus, every file will require "write" protection which restricts the capability to add data or modify data to only those persons authorized to alter the data. Some data will also have to be provided retrieval or "read" protection. For instance, access to an item such as a contractor's bid proposal on a Request for Proposal would be restricted to only a few people. Three levels of security should be provided, i.e., field, record, and file. Security codes will be assigned to people authorized to access the data. A user's code will be matched against an authorized code list. If no match is obtained, the user will not be allowed to continue processing. If a match is obtained, the user will be allowed to access the data for which he has been granted access authorization.

- Data Base Creation and Maintenance. The DMS must provide the capability to accept user files from various types of input devices (cards, magnetic tape, disk, etc.) and create data files in the data base according to the data base description. Several structure forms should be made available, such as sequential structure, indexed sequential structure, hierarchical indexed sequential, etc. A DMS must also provide the means of maintaining data in the data base. Access will be provided to insert new records, modify fields in the existing records, and delete old records from the file in both batch and terminal modes. When data fields are present in many files, the field will be updated in all applicable files whenever an update is entered for the field.

- Process Many Types of Data. Of critical importance to MSC is the structuring of data to minimize redundancy and reflect the required data to serve management, administrative, and technical users. The following blocks of data comprise the primary types that must be processed.

  Management Data - This commercial type data relates primarily to the resources management area. It will include such items as accounting data, payroll information, personnel data, procurement data, logistics data, scheduling and planning data, etc. This data is normally updated regularly according to a fixed schedule. The time between update cycles is determined mainly by the amount of data in the application area and the rapidity of changes of the data.

  Technical Data - This data is scientific in nature, i.e., used in engineering calculations or used to describe technical data. Such items as lunar sample data and spacecraft engineering specifications would be included in this category.

  Library Data - This data is generally descriptive in nature, containing a brief amount of information about some larger item. The purpose of this data is to show a user identifying information available on a particular item. A user could, for instance, find the names of books, pamphlets, research papers, etc., on particular subjects. The graphic arts file, library file, and earth resources file are examples of data in this category.

  Textual Data - This is documentary data. A document could be entered in free form into a data file and then recalled to be edited and formatted at a CRT terminal. The final, edited copy of the document could be printed at the on-line printer and sent to reproduction for processing and distribution. Some examples of this type of data are the Skylab Data Book and Statements of Work documents.

- Simple Terminal Language with Prompting. The language provided by the DMS for users at a CRT terminal must be easy to learn and of a semantic form familiar to most users. It must prompt the user by asking questions and directing the sequence of entries as a user develops a query. The purpose of the simple terminal language is to enable nontechnically oriented people to utilize a highly sophisticated DMS. A user is asked what he wants to do, and when he answers the question, is told how to do it. The prompting part of the query could be bypassed after a user becomes familiar with the language procedures and requirements (see Appendix H).

- Short Terminal Response Time. The primary reason for a DMS and a data base is to provide MSC managers quick, direct access to the data which pertains to their operation. This makes the computer more useful as a tool for decision making. Data must be structured in such a way as to facilitate rapid

response to queries. The terminal processing routines of the DMS must be highly efficient and provide an interpretive capability in order to achieve a short terminal response time. Appendix I provides a more detailed explanation of the required terminal processing language.

- Update Data at a Terminal. A DMS must provide update capabilities in both the batch and terminal modes. The batch mode will normally be used for large volume updates, and the terminal mode for small volume updates. A manager must have the capability to add new data, change erroneous data, and delete obsolete data at a terminal to ensure the accuracy of output from queries.

- Queries Using Multiple Search Criteria. A DMS must provide a user the capability to state more than one data search condition. The multiple search criteria capability enables a terminal user to enter many different search conditions in one query. Quick retrieval of specific data is thus provided. There should be no limit on the number of search conditions that a user could state in one query. Boolean connectors (and, or, not) would be used to connect the search conditions.

- Terminal User Selection of Displayed Data. A DMS must provide the capability for terminal users to display any data field in the data base. The users must not be limited in the data they can view, except for security limitations. In addition, variable output report format should be provided such that a user need not be concerned about formatting the data that is to be displayed. Automatic spacing between columns of data should be provided as well as a meaningful name for the headings of each column of data. The DMS should also provide a means of inserting dollar signs, commas, asterisks, periods, etc., into the data that is displayed as the user requires.

- Simultaneous Queries of the Same Data. The DMS must provide capabilities for simultaneous queries of the same data by users at different terminals. Through this capability a terminal user would not be delayed in accessing the data base at any time, except, of course, when the requested data is being updated by another user. Whenever an item of data is being updated, no user would be allowed to access the item until the updating action has been completed.

- Keyword Search of Data. Many MSC groups could justify the installation of a DMS on this feature alone. All library type data files would utilize this capability extensively. This feature allows a user to enter a keyword at the console and to retrieve all the information in a file which relates to that keyword. The keyword may be a subject, author, mission number, site number, etc. For instance, all papers or books written by a particular author could be retrieved, all information in the earth resources file for a particular subject could be retrieved, and the engineering standards for a particular subject could be retrieved. Capability to use combinations of keywords for search criteria should also

be provided. This capability would produce an answer set that would contain only data that related to all of the keywords specified in the query.

- Hard Copy of Terminal Displays. Terminal users will need the capability to obtain a printed copy of the contents of a CRT display. Hard copies are needed so users can take viewed results back to their desks for analysis, thus releasing terminals for other users. The hard copy could also be used for actual production purposes. Some Xerox type devices are available for this purpose. Typewriters, printers, and teletypes could also be used.

- Terminal Arithmetic Operations. Data in areas such as payroll, accounting, logistics, and procurement require the arithmetic operations add, subtract, multiply, and divide. Internal decimal point alignment (floating point arithmetic) must be included with these operations. The DMS must provide the capability to perform these operations on two or more data fields. These data fields could be contained in the same data record, or they could appear in data records from different data sets. In addition, the DMS should provide the elementary mathematical function routines. This will enable an engineer or scientist to solve complex equations at the terminal.

- Sort and Merge. The DMS must provide capability to rearrange data that has been retrieved from the data base into a new sequence as requested by a terminal user. Data files are normally structured in one fixed sequence. If a sequence different from the structured sequence is necessary to satisfy a query, the user would designate a new sort key for the file, and a sort routine would then create a work file in the new sequence. The sort routine should have the capability to arrange data in either ascending or descending sequence and to sort negative numbers. The merge routine should be able to combine two or more data files according to a user specified sequence.

- Data Name Synonyms. Some data items are called by different names among the various MSC groups. For instance, one MSC group may reference a data item as contract number, while another group may reference the same item as purchase order number. Many such data similarities exist at MSC. By means of synonyms, different users can query an item of data using the name familiar to them.

- Inter-File Data Query and Update. The DMS must provide a user with the capability to obtain data from many different files with the same query. For instance, a query may obtain an employee's name from the personnel file, his hours worked from a labor file, and payroll information from the payroll file. With this capability, data redundancy is greatly diminished. This would provide important data storage savings since many files at MSC carry the same data items. If it is necessary for a data item to appear in more than one file, an update of this item should automatically update the item in all files in which it appears.

- Audit Trail of Data Updates. An audit trail is a record of the update actions performed on data in the data base. The DMS must provide the capability to keep a record of all changes made to a data file. The data base will be frequently written on magnetic tape as a backup safety precaution. If the data base is destroyed, it may be recreated using the latest backup tape. Audit trail(s) containing the update actions recorded since this backup tape may then be reentered in the data base. Thus, total recovery would be achieved.

- Create, Save, and Reuse Terminal Queries. Since the terminal language will be a simple, English type language, nontechnical users will be able to create their own queries. Some queries are of a repetitive nature; therefore, if a user determines that he will be entering the same query repeatedly, the DMS should provide the capability for a terminal user to save such queries. When a future request requires a stored query, the user need only enter the name of the query, and the query would be called up and executed. Much terminal user time and effort will be saved by this capability.

- Temporary Saving of Answer Sets. The answer set resulting from some queries may contain more data than is desired by the terminal user. He may want to add other search criteria to reduce the answer set data volume. On other occasions, a user will need to take a hard copy of the terminal display and analyze it before he proceeds with other queries. In such cases, he may wish to perform different actions on the same data set created in a previous query. The DMS should, therefore, provide capabilities to store a response to a query and allow that answer set to be recalled as input for a subsequent query.

- Purge of Obsolete Data. Data on the data base can become obsolete for a number of reasons: The data could outlive its usefulness, it could have been input erroneously, data items could be marked for delete during a normal update run yet retained in the data base, and/or new work procedures could make entire blocks of data obsolete. Therefore, the DMS will provide routines to reorganize individual data files within the data base and delete all records that have been flagged as obsolete.

- Editing and Validating Data. When new data is added to the data base, the DMS will provide a validity check and permit data to be entered into the data base only when certain validation criteria are met. The DMS will also provide editing capability for both numeric and alphanumeric fields.

- DMS Error Recovery Without Aborting. Errors can occur during processing which could cause system failures. This could happen due to a number of causes such as area overflows, division by zero, etc. If this occurs during DMS processing, control should be returned to the DMS, not to the operating system, so that the necessary core dump will be taken and an error message displayed on the CRT console screen. The DMS could then direct the terminal

user to initiate a new processing request. This capability will save considerable time by allowing processing at all terminals to continue and not require reinitializing of the DMS.

- Easy to Modify and Expand DMS. The DMS should be written in modules in order that modifications to one functional area will not impact other areas. A module could be modified without impairing the operation of other modules. Also, if other facilities were to be added, such as textual data editing or a graphics capability, they would be written as separate modules. The DMS should be written in a machine independent language. This will facilitate conversion or modifications when computer hardware is changed or upgraded. Appendix I contains a more detailed discussion concerning the DMS language.

3.3 DESIRABLE DMS FUNCTIONAL CAPABILITIES

It is also highly desirable to include certain other capabilities for reasons of greater processing efficiency and flexibility to the user. Although these capabilities are not mandatory to system operation, the increased user effectiveness which they provide is of great value.

- Variable Length Data Fields. Some MSC applications could greatly utilize the variable length data capability. At present items such as addresses, names, remarks, etc. are limited to specific lengths and in many cases the data has to be abbreviated. Conversely, much storage space is wasted by comments and textual type data that does not fill the space allocated for it. The capability to make these fields variable length would better facilitate MSC's data requirements.

- Textual Document Editing and Formatting. This capability allows unedited documents to be input into the data base. The user then edits and formats the documents at a terminal to prepare them for printing. This capability will require a functional keyboard in addition to the terminal console keyboard. It also provides a rapid and highly flexible means of editing documents without requiring the many intermediate typed versions of the document. The final edited and formatted version of the document can be printed using the on-line printer at the terminal.

- Terminal Graphics. Many people at MSC expressed a desire to have a terminal graphics capability. The graphics capability allows a user to create drawings and objects on the CRT using diagonal lines and points, to display graphs of statistical information, etc. Areas such as engineering design, accounting, and graphic arts are just a few examples of applications which could utilize the graphics capability.

- Remote Job Entry. This capability allows a terminal user to call up and execute a job stored in a system library. A job may consist of one or more

programs designed to perform specific tasks. The remote job entry capability allows a user to quickly execute prestored jobs from a terminal, thereby saving the time and effort required in preparing and submitting the jobs for the batch mode.

- Geographic Type Data. Earth resources data needs to be reported by area and by points. Earth resources at present is utilizing the GEOREF system but will eventually change over to the UTM system to make earth resources data compatible with outside users in the way they define the coordinates of the area for which the data applies.

- Access Data Using Different Languages. The use of COBOL and FORTRAN as programming languages is almost universal, and these are the basic languages utilized by MSC. Therefore, the DMS should include the capability to write programs in these languages. Programs written in these languages could also utilize DMS functions and access the data in the MSC data base.

- Statistical Analysis of Data. Many people expressed a desire to have the DMS perform some statistical analysis of their data. (This was especially true in some of the resources management areas.) Statistical analysis will be tied in very closely to the graphics capability. Statistical analysis routines should be callable by the DMS to provide this capability as it would provide terminal users with routines to obtain such items as regression analysis, chi squares, least squares fits, etc., as aids in decision making.

- Conditional Processing. This capability allows a DMS to initiate or bypass tasks or jobs based upon conditions encountered during processing. These conditions could consist of types of data processed, unusual events or errors encountered, or a series of required events to have taken place before a conditional task can be executed. This capability would not only significantly save computer processing time but also help to eliminate the wasted processing of erroneous data.

- Automatic Scheduling of Processing. Most of MSC's computer activity is accomplished according to a preset schedule. File update runs and report production are done weekly, semi-monthly, and monthly. All of these activities could be programmed into a "scheduler" module and added to the DMS. The MSC applications would then be automatically processed by the DMS according to the scheduling criteria specified for each application. There would also be provisions for a user to override the preset schedule. A terminal user could change the application schedule and cause applications to be immediately executed. Automatic scheduling would help produce a more efficient utilization of computer hardware.

- Validate Data Base Integrity. The data base should be audited periodically to ensure validity of data. The audit would check data items against edit

criteria such as size or range limitations and type of data (alphabetic or numeric). If a data item is dependent on other data items, a check could be made to ensure the item meets all conditions imposed upon it by other items. An example of this might be salary, i.e., the amount paid to an employee would be computed from hours worked, pay rate, overtime, income tax, social security tax, etc. It is also possible that portions of the data base could be erroneously modified or destroyed due to either hardware or software malfunctions. These portions could be restored from the data base backup tape and the audit trail records.

- Lockout During Data Update. Two or more users could access the same data simultaneously. If none of the queries involve update actions, they will be processed concurrently. However, once an update command against an item of data has been issued to the DMS, all queries and other processing requiring this data will be delayed until the update has been completed. This should be at the record level, thus allowing other users to query all records in the data set which are not in the process of being updated.

- Computer Transferability of the DMS. If the major portions of the DMS are written in a language which is virtually machine independent (such as COBOL), the effort to rewrite them will be greatly reduced should it become necessary to transfer the DMS to new computer hardware. This would result in considerable cost and time savings. The DMS would also be more easily maintained if written in a machine independent language. Appendix I contains detailed discussions of this desirable capability.

- Inverted Data Files. An inverted file capability is a powerful means of rapidly accessing data. Inverted files essentially consist of a series of different sort key index sets for any application data file. Each sort key index set contains records in a specific sequence and application data record address pointers. In a query, a user will specify the sort key index set which will give him the most direct access to his data. It is recommended that the inverted file capability be provided for the data items which are used most frequently in referencing or searching the data file. This is necessary in order to minimize the random access storage required by inverted files, which could be quite large.

3.4 REQUIRED HARDWARE FOR THE DMS

Only nominal special hardware and configuration changes over and above those which already exist at MSC are required to support a DMS. However, in some areas, such as direct access storage devices, it will be necessary to increase capacity as data files are added.

- Local and Remote Terminals. The DMS hardware must provide for both remote and local terminal processing. Remote terminal processing requires

the use of common carrier lines (e.g., telephone lines) between the terminal and the computer processing unit. A modem is required at each end of the common carrier line. A modem is a unit used to provide a data transfer interface between the computer and common carrier line (or between a terminal and the common carrier line). Local terminals normally utilize hard wiring (direct connection) from the computer to the terminal display control unit. Local terminals, however, should also be able to optionally utilize modems instead of the hard wiring. In fact, it is recommended that whenever possible, modems be widely used for local terminals, especially where a terminal location is likely to be changed. This method of data communications provides significant flexibility for placement and relocation of terminals without the necessity of considerable data line, adapter, and control unit hardware replacements or modifications. Hard wiring should be utilized sparingly and only for those local terminals that are almost certain not to be relocated and made remote (see Figure 3-1).

Interactive terminal consoles which allow users to specify their processing requirements must be provided. Terminal output devices (e.g., CRT, printer, typewriter) must be available to display the requested information that the terminal processor routines of the DMS obtain from the data base. A terminal keyboard/CRT with alphanumeric capability should also be provided. MSC has many different types of data display requirements. Provision must be made for pictorial displays of numerical, graphical, textual, and commercial accounting types of data. This requires a complete character set of all alphabetic letters, all numbers, and special characters such as *, $, #, etc. The CRT must have the capability to display all characters in the character set.

A terminal hard copy device should be provided that can produce a printed copy of the entire generated results of a query or the contents of a single CRT display screen. These devices could be typewriters, teletypes, printers, or Xerox copier type devices. These devices are necessary in order to give terminal users permanent copies of query results. Most users will need to review these hard copies and perform some analysis on the information. Without a hard copy capability, a user's analysis of displayed results would have to be performed at the console while the query results are available. This is very inefficient use of terminals. Hard copy capability will free terminals for subsequent users. In addition, a permanent record of the answers to queries could be made available to other people as well as to the person who performed the queries.

- <u>Direct Access Storage Devices</u>. The large volume of current MSC applications data plus the probable increase in size of some application data such as earth resources will require a large random access storage capacity. Earth resources could currently occupy approximately 200 million character positions of storage, if all the data they have at present were structured into the data base. This file

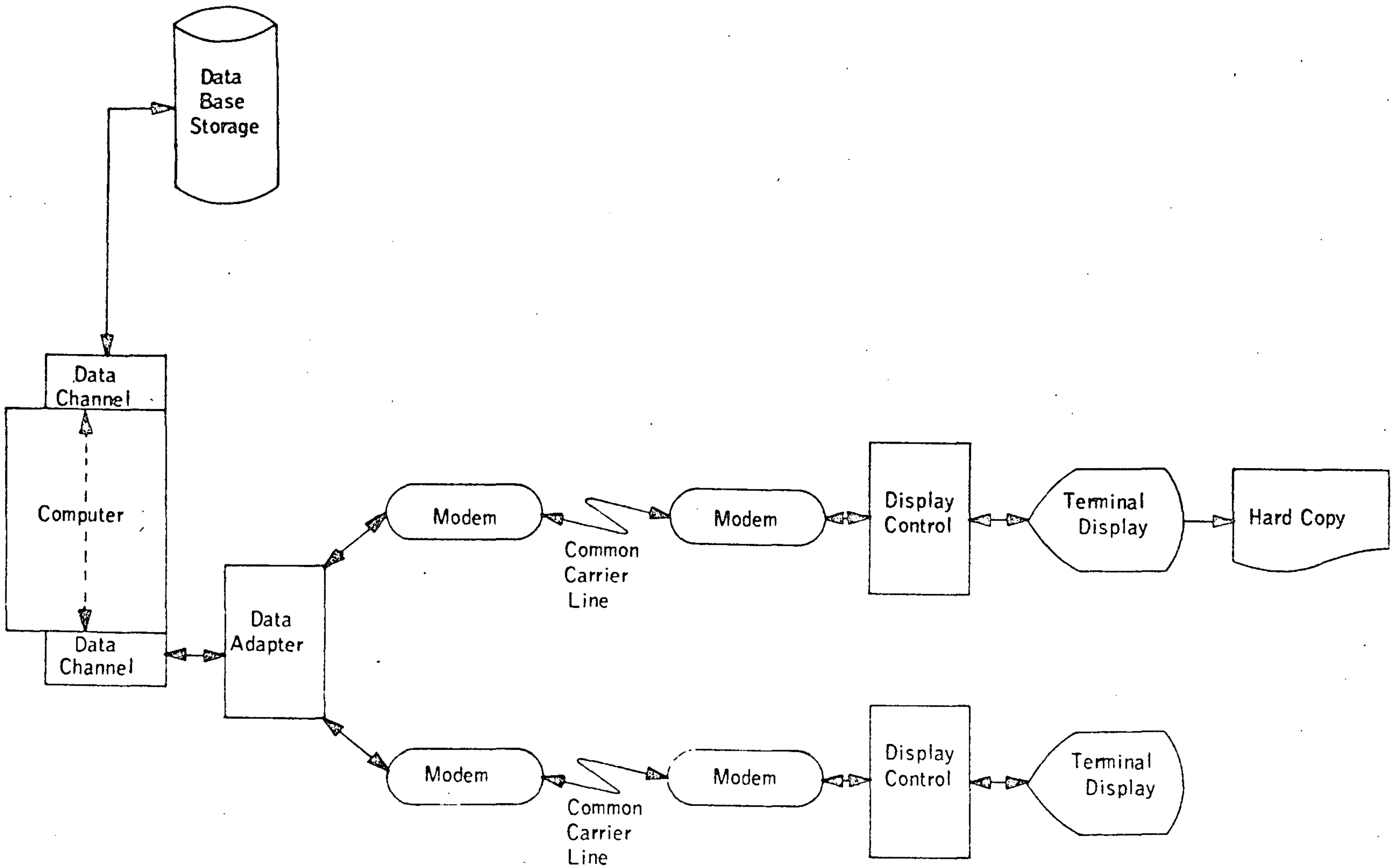


Figure 3-1. Required DMS Hardware

will multiply in size during the Skylab program. The lunar sample data is another application which will grow much larger in the future. Most of the currently active files at MSC are static and will not increase appreciably in size during the Skylab program. Some of the files, however, are dynamic and will result in a veritable data explosion. There will, therefore, be a need for large storage capacity in the random access storage devices. History tapes are normally created at year end on most of the active files, but these history files are not active. They are stored mainly to preserve a record of the previous year's activity.

It is also necessary that a DMS provide for many types of data structures, the most important types being indexed sequential and hierarchical sequential. These methods allow for direct access to specific data items and the chaining together of like data items. The very size of MSC files makes it imperative that some method of directly accessing any data in the data base be provided by the DMS. If only sequential searches of data were available, queries could take hours to complete. Each application must be analyzed to ensure the most efficient structure in the data base, and also the volume of direct access storage required to efficiently and economically support each application.

- Large Core Storage Capacity. Many of the applications at MSC are extremely large, and some applications data areas such as earth resources will grow to huge proportions through the Skylab and Space Shuttle programs. Queries of these data files could create very large answer sets. Enough core storage must be available to handle such queries while at the same time allow other programs or jobs to execute in other partitions of core storage (multi-programming capability). A large core storage capacity would provide more rapid response to terminal users since a major portion, if not all, of the data in large answer sets could be contained in core storage and thereby be readily available for terminal display. In addition, many users at various terminals will be querying the data base simultaneously, creating answer sets in core storage. Because of all these important factors, a large core storage will be required.

3.5 DESIRABLE HARDWARE FOR THE DMS

To make full use of expanded capabilities of the DMS, certain options should be considered. Through the use of additional hardware capabilities, greater efficiency and utilization may be obtained.

- Terminal Console Special Features. An auxiliary function keyboard should be provided for text data editing and formatting operations such as data insertion, data deletion, paragraphing and capitalization. Once a document has been entered into the system the functional keyboard allows a user to edit the document and prepare it for printing. Also, many people who viewed

the pilot DMS demonstrations expressed a desire to have graphics capability. If future MSC plans are to include a graphics capability in the DMS, terminals should be selected that can provide vector generation.

- Terminal Input/Output Devices. There are many printers available today which could be installed as hard copy devices at terminals. The volume and urgency of need of the hard copy output together with the economic considerations would dictate whether or not a printer would be utilized at a terminal. Typewriters could be used as a hard copy device at a terminal when low volume output is expected.

- Microfilm. Expanded use of microfilm could reduce MSC's cost in the storage and retrieval of charts, drawings, photographs and text documents. For instance, it would take approximately 3 hours and 45 minutes to print 3,500 pages of information stored on a reel of magnetic tape, but the same data could be placed on microfilm in 12 minutes. Encyclopedia Brittanica has developed a "Microbook Library" containing 20,000 volumes stored in two shoe-box sized files. There are many scanning devices on the market which make microfilm scanning a relatively simple task. Because of the simplicity of use, reduced processing costs, and conservation of storage space, many schools use microfilm in place of textbooks. Microfilm and microfiche (a type of microfilm) are now being widely used by MSC in many areas such as earth resources and engineering plant drawings. The use of microfilm for this type of data is considerably less expensive than either printing a hard copy or retaining the data (when possible in the data base).

3.6 DATA REQUIREMENTS

The broad spectrum of activities at MSC makes it a very complex facility. The DMS must be powerful enough to serve the data needs of all areas of MSC. As stated previously, a logically and efficiently structured data base is a critical part of the system. The data base must contain all data needed by management and technical users.

- Management Data. Data is needed by managers to plan activities, to schedule work loads, to perform project analysis, and to financially control their phase of the MSC operations. In short, they need performance data, and this data would be contained primarily in the commercial applications data. A manager would only utilize those portions of the data that is needed to control the total performance of his sphere of responsibility, but this data must be readily accessible to him. It must also be presented in such a way so as to not require him to spend hours analyzing it before he can formulate plans. This is a major reason why a thorough study must be made of MSC data, from the standpoint of both managers and technical users. Someone thoroughly familiar with the needs of both these groups should be engaged to perform this study. Managers, in fulfilling their functions, will normally not utilize the highly technical data that is required for solving complex mathematical and engineering

problems. Thus scientific and engineering technical data will be utilized mostly by line users, engineers and scientists. Other MSC areas of technical data include requirements for spacecraft fuel and other expendables, configuration control data, lunar sample data, failure data, control loading and text data. The many technical documents produced by MSC, such as the Guidance System Operations Plan, should be made available for Center-wide use. This could be accomplished through utilization of the library retrieval, keyword capabilities provided by the DMS.

- Static and Dynamic Behavior of MSC Data. Most of the currently active files in the management area are not growing appreciably in size and thus are static in their behavior. This data was originally designed and created to meet MSC's needs for the Gemini and Apollo programs, and will be used for future programs. A few of the data files, however, are dynamic, such as earth resources and other library files. These files are in a constant state of growth. Most of the files in the technical area that would be contained in the MSC data base are static, but there are some dynamic files. Lunar samples is the largest dynamic file. It will continue growing as more and more tests are made on the moon rocks. Flight scheduling is a very active file. Its size varies depending on mission requirements. Data behavior varies widely between the various MSC groups. A data base to contain the MSC data would have to be a well planned and carefully structured entity.

- Impact of Space Station and Space Shuttle on Data Volume Through 1975. Most of the management data which is static now should remain relatively static through 1975. The requirements for resources management should not increase appreciably because of new programs such as the space station and space shuttle. Earth resources data will be extremely dynamic, however. Their data is cumulative. The library data will be somewhat dynamic, too, since more papers, documents and literature will be published as a result of these programs. Technical data should also remain relatively static. Again, the lunar sample data will be dynamic. This is caused by the continued testing of the rock samples and the constant influx of data from the experiments left on the moon. Data for the scheduling of flight activities for the Skylab and Space Shuttle missions will also be in the MSC data base. It is expected that this technical data will have a high level of activity. The volume of this data is anticipated to fluctuate significantly depending on the number and complexity of the flight activities during Skylab and Space Shuttle missions. There will also be a large amount of raw telemetry data and engineering data from the Skylab and Space Shuttle missions. Only condensed summaries of this data need to be considered for implementation into the Center-wide data base.

- Data Adaptable to Data Base Type Operations. The general guideline to follow in implementing data into the Center-wide data base is to structure that data most needed by MSC managers to aid them in decision making and planning. Logistics, procurement, and accounting files are prime candidates. Flight

scheduling should be among the first to be implemented. Since NASA will be playing a constantly expanding role in the environmental sciences through the Skylab program, most of the environmental data should be structured into the data base. MSC will experience increasingly heavier demands upon this data as it becomes available to them. Earth resources is the major file in this area. The DMS and Center-wide data base are management tools to be used as aids in decision making. So again the guideline to follow is to structure data needed to aid in decision making and planning.

3.7 DATA ITEM DICTIONARY

A data item dictionary must be provided for MSC which contains a description of each data item in the MSC data base. This will enable the DMS users to become familiar with the content and organization of the data in the data base. This data dictionary will completely describe the data base by providing the necessary and pertinent information concerning each data item in the data base.

There are many advantages for MSC in having a data item dictionary. The interchange of data among the many MSC organizations will be greatly facilitated. The development of standard information and data systems will also be facilitated. It will also facilitate the integration of MSC application systems and direct computer-to-computer communications. There will be a cost savings to MSC since redundant data items would be eliminated and time-consuming new development of data items and processing already available would be avoided.

The following information will be contained in the data item dictionary for each data item in the data base:

- Data Item Name. A precise, meaningful name will be assigned to each MSC data item. CONTRACT TYPE would be a typical item name.

- Coded Name. The coded name for the data item will be used by terminal users and in writing programs for batch processing. For CONTRACT TYPE the coded name could be CONTYPE.

- Item Description. The data item size, type of data (numberic, alphanumeric, etc.), and the decimal point position will be specified. An item description of "9999V9" could represent a five digit number having one decimal position.

- Security Code. Government security classifications of SECRET, CONFIDENTIAL, OFFICIAL USE ONLY, and RESTRICTED will be specified, when applicable, to classified data. Sensitive data that will be accessible only to certain persons, such as payroll and contract data, will also be assigned a security code.

- Synonym Names. Any other names by which this data item is referenced will be specified. TYPE OF CONTRACT could be a synonym name for CONTRACT TYPE. Similarly, the data item's coded name CONTYPE for file A could be CONTYP for file B.

- Access Item. If a terminal user has a need to query the data base using the data item in a search argument, the item will be designated as an access key data item.

- Edit Criteria. The edit specifications such as range and minimum/maximum values for the item will be included. A numeric item, for example, might have a valid range of only 50 - 75 inclusive.

- Code Table Name. If an encode/decode table is to be used to translate the actual item value to a coded value (and vice versa), the code table name will be given.

- File Name. The name of the data file containing this item.

- Using Applications. All MSC application subsystems, such as Logistics and Inventory Control, which use a particular data item.

- Description of Use. The meaning and significance of the data item to the using applications.

- Update Responsibility. The MSC application subsystems and groups authorized to update the data item.

- Terminal Usage. A description of any special procedures or considerations to be taken in retrieving, displaying and updating the data item at a terminal.

- Item Origination. The name (or identification number) of the input transaction form containing the data item. Equivalent information should be supplied if a standard input form is not used. For data items internally generated by application programs, the name (or number) of the application program should be used.

- Remarks. Additional information required for a complete understanding of the data item, such as a formula used to compute the item values.

The Data Item Dictionary will have a complete listing of the content and organization of all data items in the MSC data base. There will also be functional area data dictionaries which contain only those data items relating to particular MSC activities. These smaller data dictionaries will be more meaningful and usable since only pertinent data items for the particular MSC activities will be in them.

3.8 DATA SOURCE DOCUMENT INDEX

In conjunction with the data item dictionary, a data source document index will be provided which describes all input transactions and other submittal forms used by MSC and contractors for entering data items into the data base. A description of each data source document and the data items created or updated in the data base by using that source document will be contained in the index. This index will greatly facilitate the coordination and integration of many data processing activities throughout MSC and thereby significantly reduce costs.

The following information will be contained in the index for each MSC and contractor data source document:

- Originating Source. The MSC organization or contractor responsible for submitting the data.
- Originating Location. The location of the submitting organization (if not at MSC).
- Input Form. The name and identification number of the input transaction form containing the data item. If a standard input transaction form is not used when entering the data item, equivalent or appropriate information will be included.
- Submittal Frequency. The frequency that the data item will be submitted; one time, weekly, monthly, other periodic times, or as required. An exact time of a particular day of the week or month, when pertinent, should also be entered.
- First Submission Date. The date that the data item was first submitted.
- Transmission Format. Input transaction is contained in a punched card, magnetic tape, hard copy, etc.
- Transmission Method. Method by which input transactions are received, such as mail, hand carry, telephone, etc.
- Security Classification. The classification of the entire data submission will carry the highest classification of any data item being submitted.
- Responsible Application. The name of the application subsystem or group responsible for processing the data and entering it into the data base.
- Coded Names and Descriptions. The coded name used in the data item dictionary for each data item contained in the data source document will be listed. If the item description (e.g., item length) is different than that specified by the dictionary, the differences should be described.

Some data items in the data base will be created by an application program. These internally created data items serve special purposes, such as data record type indicator and accumulation or total count items. Information concerning these data items will be contained only in the data item dictionary.

CSC

SECTION 4 - SYSTEM IMPLEMENTATION

SECTION 4 - SYSTEM IMPLEMENTATION

This section discusses the major items which must be given consideration in the implementation of a data management system at MSC. The necessary degree of management involvement and a projected schedule are discussed. Also, the manpower and equipment requirements for a suitable system are described.

4.1 MANAGEMENT INVOLVEMENT

In major systems endeavors, it is imperative that management participate and involve themselves in its achievement and success. In organizations where the computer systems and the data base are regarded as major resources and as important tools in achieving goals, management must play a strong role. An automated system, to be an efficient tool, requires a high degree of management.

The prime management functions of control, scheduling, and decision making must be applied by MSC management throughout the phases of system development, implementation and operation.

- Development. Once the decision is made to implement a DMS with a Center-wide data base, MSC management must decide whether to acquire a currently operational DMS or to design and build a completely new DMS.

  The existence and use of a DMS and Center-wide data base will require a change in computer utilization concepts. Individual managers will no longer have proprietary rights to their data except in cases where the data is sensitive or classified. MSC management must instigate a mode of operation which will change the thinking of MSC personnel to more of a "Center activity" level, to a common sharing of data.

  A realistic development schedule must be established to ensure implementation and operational deadlines will be met. The time element is critical. MSC needs a DMS "up and running" before Skylab missions are flown. Flight scheduling for the Skylab missions could be utilizing a DMS at the present time. Acquiring a currently operational DMS would minimize development time and provide MSC with DMS capabilities almost immediately.

  Any modifications or enhancements in the DMS design must be approved by MSC management. They must be satisfied that any and all changes will meet the overall needs of MSC.

- Implementation. A priority list for the installation of applications and executive modules should be established by MSC management. This list would be based primarily on the need of the various applications for DMS capabilities.

An exhaustive analysis of MSC data must be made to ensure the technically sound structuring of data sets reflecting the required data to serve both management and line users. This study should be started as soon as possible as it will consume much time and effort. It should be completed prior to the implementation of the modules to define and create the data base. This will require very careful planning and close monitoring of effort to ensure data availability for the data base when the modules to define and create it are installed.

- Operation. MSC management must maintain control of the DMS and the data base. No one should be allowed to alter the contents of the data base without the consent and knowledge of management. Any changes to the data base should be published for all interested parties. MSC groups must reorient their thinking to Center-wide activities rather than group activities. A control group of MSC managers should be formed to ensure these DMS operations produce the desired DMS effects.

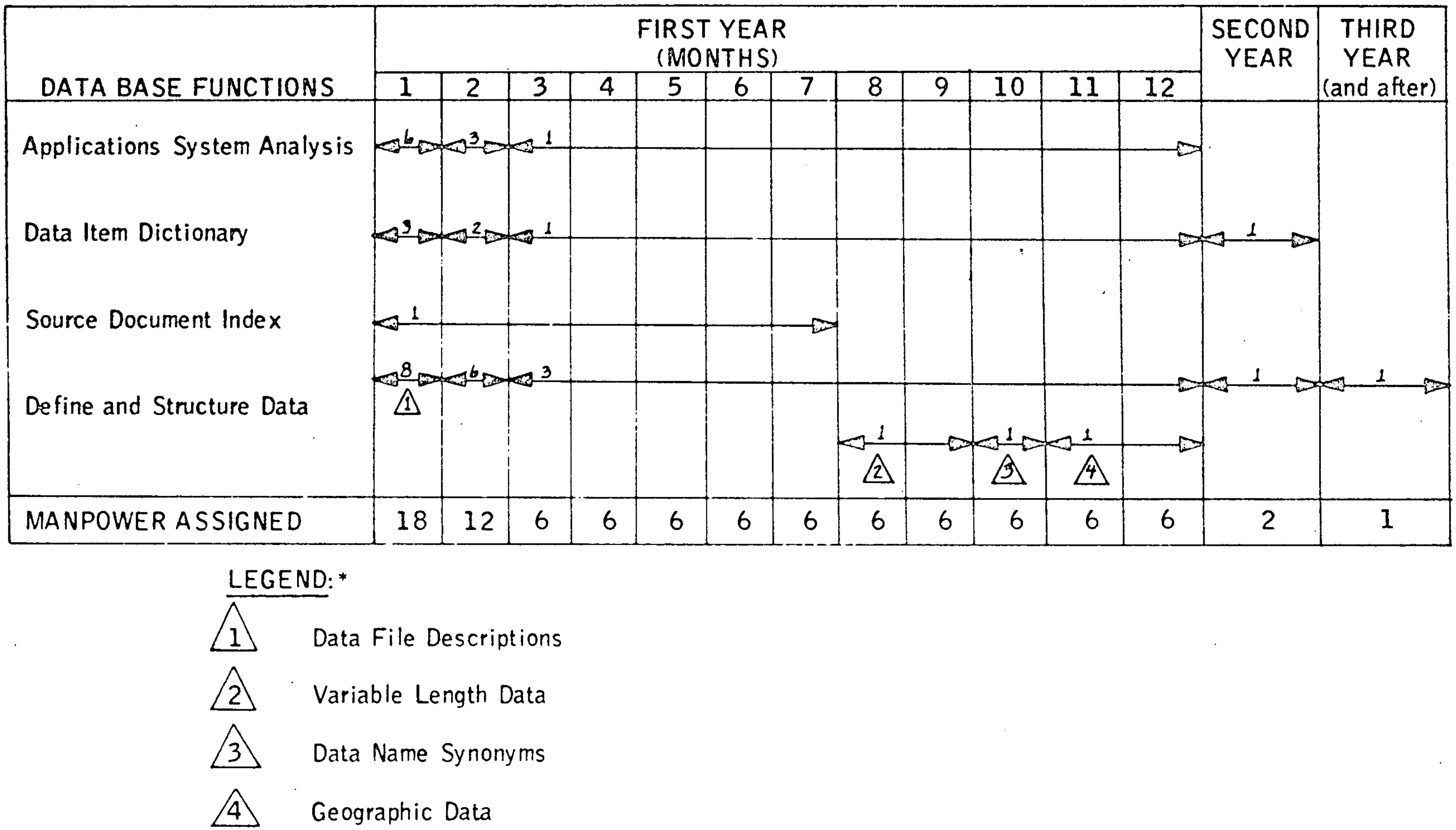
  The DMS with a data base can be a tremendous management resource item if users will cooperate and use it effectively. Management must establish and publish procedures for the DMS. In addition, they must determine the best schedule for applications to be run. Batch runs and massive updates are best run on third shift, when the real-time use of terminals is extremely low.

  Management should utilize two powerful tools that are available for controlling the content of the data base and application system activities. These tools are the Data Item Dictionary and the Data Source Document Index (which are discussed in Section 3). User's manuals for data base maintenance and DMS queries and operations should be published. A DMS procedures manual should also be published, and adherance to the procedures set by MSC management must be enforced by them. The best DMS and a sound, logically structured data base are of little use if people will not give up their proprietary interests and cooperate and share for the success of a larger enterprise.

  Management must also approve or disapprove future applications and file additions to the data base. A control group which knows the complete status of the data base and DMS can weigh all the factors of available storage area, data requirements of the new application, real-time need, etc. Individual users must not be allowed to make such decisions. What may be best for an individual could well hinder all other users. Only managers who know the "big picture" can thus make the wisest decisions on what applications to add, how to structure the data, where to place terminals, etc.

4.2 PROJECTED SCHEDULE BY MAJOR ITEMS

The implementation charts shown on the following pages (see Figures 4-1 through 4-3) indicate the manpower effort that is expected to be required to completely implement the

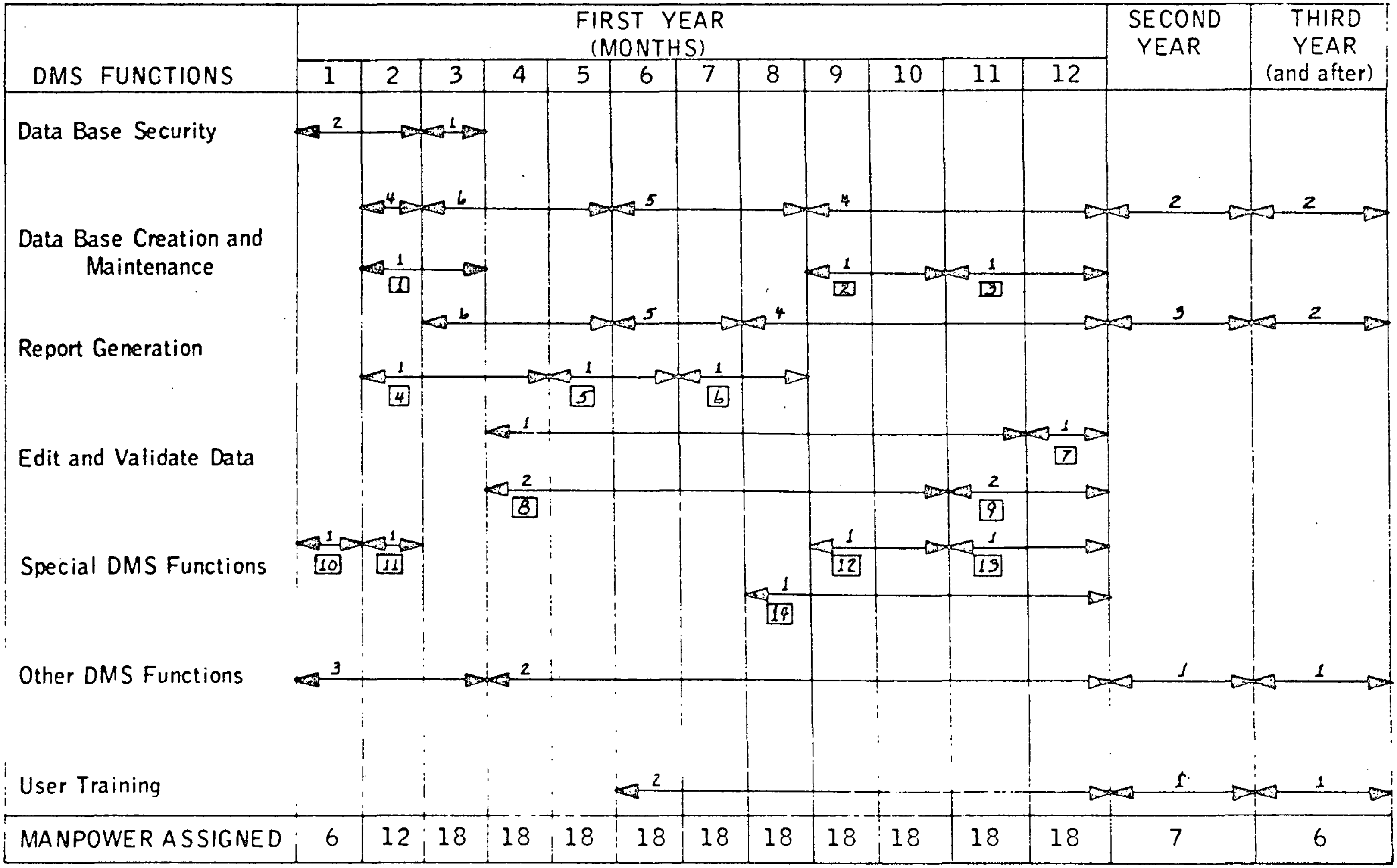


*See Table 4-1 for explanatory details.

Figure 4-1. Data Base Functions Implementation

Table 4-1. Data Base Functions

DATA BASE FUNCTION	FUNCTIONS TO BE PERFORMED
APPLICATION SYSTEMS ANALYSIS	A comprehensive analysis of current and planned MSC data processing applications must be performed. The major purposes of the application systems analysis are: • To determine what data items should be contained in each application file (of the data base) and in the Data Item Dictionary. • To review MSC source documents to facilitate coordination of data base input throughout MSC and to provide a more standardized source document format. • To determine if various MSC application systems can be integrated to form a related and coordinated network of activities throughout MSC.
DATA ITEM DICTIONARY	A dictionary of all data items that will be stored in the data base must be created and maintained (refer to Data Item Dictionary in Section 3). For ease of update and in providing center-wide utilization, the dictionary should be stored on magnetic tape (or disk). Computer programs should be written to update and list the latest, approved version of the Data Item Dictionary for center-wide circulation and use.
SOURCE DOCUMENT INDEX	An index of all source documents used for creating or updating data in the data base must be provided (refer to Data Source Document Index in Section III). The index should be stored on magnetic tape (or disk). Update and report programs should be written to maintain and list the Source Document Index.
DEFINE AND STRUCTURE DATA	The application data files that are to be structured into the data base must be defined. The data items contained in each application file selected must then be defined. The most efficient and advantageous method of structuring the data items in each file must be determined and then described and defined for utilization by the DMS.
1 Data File Description	Each application data file to be structured into the data base must be defined using the data description language provided by the DMS.
2 Variable Length Data	Provision must be made for variable length data in many of the application data files in the data base. The DMS routines that process variable length data should be examined for processing efficiency and for user requirements in defining the data.
3 Data Name Synonyms	A synonym capability will be provided by the DMS. Each data item in the application files should be examined for synonym names that are currently used by various MSC groups.
4 Geographic Data	The DMS must add the capability for defining and processing data using geographic coordinate positions or codes. The method of defining geographic data should be standardized for all application files in the data base.



LEGEND:*

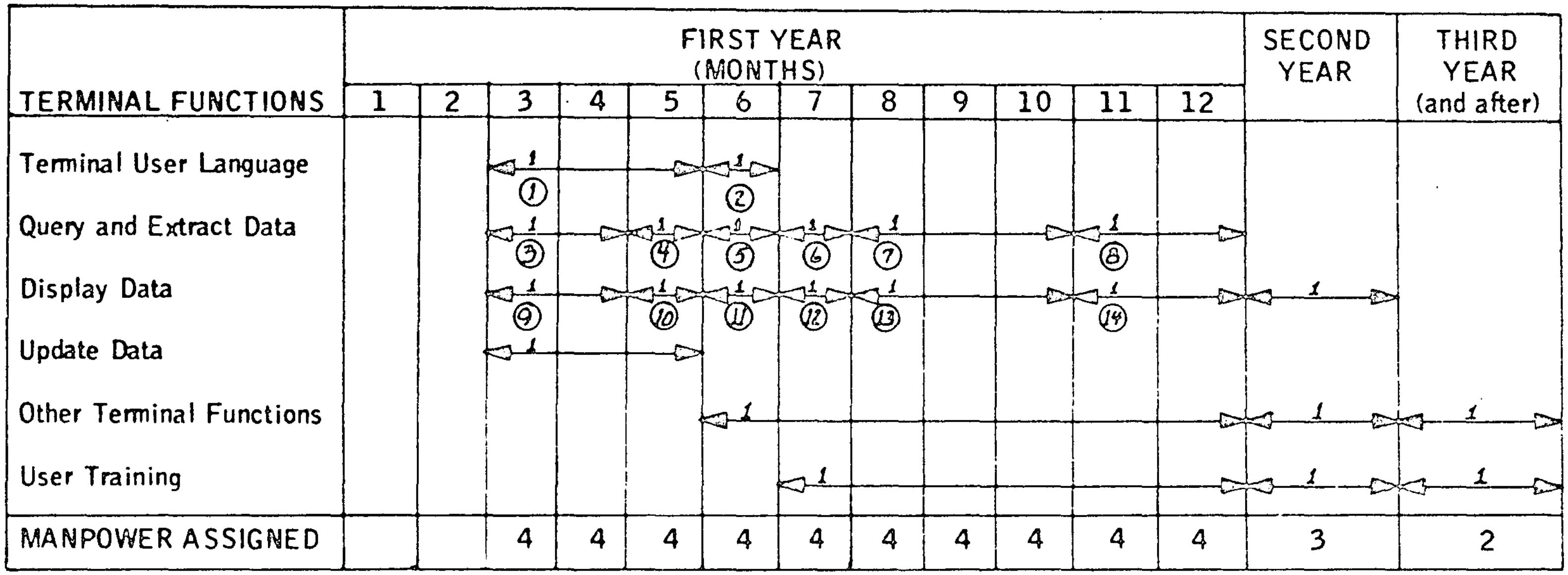
1	Process Many Types of Data	8	Textual Document Editing and Formatting
2	Audit Trail of Data Updates	9	Validate Data Base Integrity
3	Lockout During Data Update	10	Easy to Modify and Expand DMS
4	Access Data Using Different Languages	11	Computer Transferability of DMS
5	Statistical Analysis of Data	12	DMS Error Recovery without Aborting
6	Conditional Processing	13	Remote Job Entry
7	Purge of Obsolete Data	14	Automatic Scheduling of Processing

*See Table 4-2 for explanatory details.

Figure 4-2. DMS Functions Implementation

Table 4-2. DMS Functions

DMS FUNCTIONS	FUNCTIONS PROVIDED BY THE DMS	FUNCTIONS TO BE EXPANDED OR ADDED
DATA ACCESS SECURITY	User security codes are provided. Read/write protection is provided at the file, record, and data item levels.	Ease and flexibility could be improved in maintaining user security codes and in assigning data access security codes at the file, record, and data item levels.
DATA BASE CREATION AND MAINTENANCE	File create and update functions are provided. A simple means is provided to copy or translate existing COBOL data files into the data base (the vast majority of MSC data that will be structured into the MSC data base was created by UNIVAC 1108 COBOL programs).	Capability to update other types of data must be added (e.g. textual and geographic). Modifications will be required for existing MSC application programs that will create and update data in the data base. Translating of the selected data files into the data base must be done.
1 Process Many Types of Data	Management, technical and library type data can be processed.	A textual data editing and formatting capability must be added as will a geographic data processing capability.
2 Audit Trail of Data Update	The changes to the data base are recorded only.	The audit trail must be expanded to contain the additional information required for maintaining data base integrity.
3 Lockout During Data Update	Capability not provided.	The capability must be provided that will prevent other users from accessing any record being updated.
REPORT GENERATION	Comprehensive report generation routines are provided.	Modifications will be required to MSC application programs that now provide batch reports.
4 Access Data Using Different Languages	Data can be accessed only using the DMS language and assembly language.	Capability must be added to access data using other languages, e.g. COBOL and FORTRAN.
5 Statistical Analysis of Data	Only trigonometric math subroutines are provided.	Flexible and expanded data analysis routines must be provided.
6 Conditional Processing	Capabilities provided only at the application job step level.	Processing must be able to be made conditional at all levels - subtask, task, function, application job step, and application system.
EDIT AND VALIDATE DATA	Capability not provided (user routines must be entered)	A DMS encode/decode data item capability must be added. Character insertion and modification must be provided. The DMS must also use the specified data item criterion, e.g. data range in updating the data base.
7 Purge of Obsolete Data	Capability not provided.	Capability must be provided for authorized persons to direct the DMS in the purging of obsolete data.
8 Textual Document Editing and Formatting	Capability not provided.	A textual document data processing capability must be added.
9 Validate Data Base Integrity	Capability not provided.	Data base validation routines must be added to ensure that portions of the data base have not been erroneously modified.
SPECIAL DMS FUNCTIONS	Many additional functions will be provided by the DMS.	Certain other highly desirable DMS functional capabilities must be added.
10 Easy to Modify and Expand DMS	The DMS will be organized into separate functional component routines although not highly modularized.	The DMS must be made highly modularized and, for batch processing functions, written in a high level language.
11 Computer Transferability of DMS	The DMS will be written mainly in a high level language thereby facilitating computer transferability.	When the DMS is being implemented, functional modules should be examined to ensure capability of being transferred to other computers.
12 DMS Error Recovery Without Aborting	Error recovery routines will be provided for the major user functions.	Error processing must be expanded to prevent aborting due to any application batch processing or terminal user entry.
13 Remote Job Entry	Capability not provided.	DMS routines to interface with the operating system must be provided to allow remote entry of user jobs.
14 Automatic Scheduling or Processing	Capability not provided.	A scheduler supervisor must be added which will control the running of production MSC application jobs.
OTHER DMS FUNCTIONS	Capability not provided.	Provision should be made for other desired DMS functional capabilities not provided by the DMS.
USER TRAINING	A DMS programming language and procedures manual will be provided with the DMS.	Training classes and DMS consultation must be provided to familiarize users with the DMS programming language and procedures for accessing the data base.



LEGEND:*

1. Simple Terminal Language With Prompting
2. Short Terminal Response Time
3. Keyword Search of Data
4. Arithmetic Operations
5. Queries Using Multiple Search Criteria
6. Simultaneous Queries of Same Data
7. Inter-File Query and Update
8. Create, Save, and Reuse Queries
9. User Selection of Displayed Data
10. Sort and Merge Data
11. Hard Copy of Displays
12. Saving of Answer Sets
13. Inverted Data Files
14. Graphics

*See Table 4-3 for explanatory details.

Figure 4-3. Terminal Functions Implementation

Table 4-3. Terminal Functions

TERMINAL FUNCTIONS	FUNCTIONS PROVIDED BY THE DMS	FUNCTIONS TO BE EXPANDED OR ADDED
TERMINAL USER LANGUAGE	A terminal language will be provided by the DMS.	The terminal language functions should be expanded and simplified.
1 Simple Terminal Language With Prompting	A terminal language with some user prompting will be provided.	The terminal language should be simplified for non-technical users with additional meaningful user prompting.
2 Short Terminal Response Time	The DMS terminal processor will provide an adequate terminal response time.	The DMS terminal processor routines should be examined for possible processing efficiency improvements.
QUERY AND EXTRACT DATA	Capability to query and extract data will be provided.	Query and extract capabilities must be expanded.
3 Keyword Search of Data	Capability not provided. It can only be simulated through use of many search arguments.	A keyword search capability must be added.
4 Arithmetic Operations	An arithmetic operations capability will be provided by the DMS.	This capability should be expanded to allow complex terminal manipulation of data items and literals.
5 Queries Using Multiple Search Criteria	Capability is provided.	This function should be examined for simplicity of use and efficiency of the processing routines.
6 Simultaneous Queries of Same Data	Capability is provided.	This function should be examined for any system problems. caused by many simultaneous users and for efficiency of the processing routines.
7 Inter-File Query and Update	Limited capability is provided for selecting data items in several files for query. Inter-file update of data items is not provided.	Capability must be expanded to allow any user desired data items in the data base to be specified for queries. An inter-file update of data capability must be added.
8 Create, Save and Reuse Queries	Capability to create, save, and reuse complete queries (unmodified) will be provided.	Capability must be provided to store complete and partial queries; retrieve and then modify, insert, and delete entries in any query before it is processed.
DISPLAY DATA	Capability is provided.	The display data function must be expanded.
9 User Selection of Displayed Data	Capability is provided for selecting data items from several files for display.	User specified display format flexibility must be expanded, and the capability added to display any user selected data items from the data base.
10 Sort and Merge Data	Capability is provided for displaying data sequenced by any combination of data items within only one file.	This function should be expanded to allow user displays to be sequenced by any combination of data items in the data base. Processing efficiency of the sort/merge routines should also be examined.
11 Hard Copy of Displays	Capability is provided for a user to specify hard copy of one CRT page or the entire answer set to the major output devices (e.g. CRT, printer, teletype).	Capability should be extended to allow user selection of a series of CRT page displays to any output device used at a terminal.
12 Saving of Answer Sets	Capability is provided to temporarily save the entire answer set.	Capability should be extended for a user to temporarily or permanently save portions or the entire answer set.
13 Inverted Data File	Capability is provided to directly access any data file record by using multiple data item indexes (inverted files). The inverted files cannot be easily modified or expanded.	Flexibility must be added in the creating and maintaining of inverted files in order to include only those data items frequently used for search criteria in queries. Processing efficiency of the query routines that utilize inverted files must also be examined.
14 Graphics	Capability not provided.	A graphics capability should be added.
UPDATE DATA	Capability is provided to update data in only one file at a time.	An inter-file update capability must be added. Capability should also be provided for update routines to be automatically called up to process and edit any modified data items.
OTHER TERMINAL FUNCTIONS	Capability not provided.	Provision should be made for other desired terminal functional capabilities not provided by the DMS.
USER TRAINING	A terminal user's manual will be provided by the DMS.	Training classes and terminal user consultation must be provided to familiarize users with terminal operations.

DMS, structure the MSC application data into the data base, and train MSC personnel in the most advantageous procedures for utilizing the DMS and the data base.

The numbers shown above the arrows reflect the expected manpower that will be required to install the data base and DMS functional capabilities. The manpower figures shown for the first month of each function being implemented will continue either to the completion of that function or until a new manpower figure is shown for the function at a later time in the chart.

Functions to be implemented were assigned numbers and enclosed in triangles, squares, or circles underneath the implemented functions arrow lines. The assigned number for each function is explained in a legend at the bottom of the chart. Each function is then described in detail in the pages following the charts (see Tables 4-1 through 4-3).

The estimated implementation manpower figures are based on MSC obtaining a DMS with only those functional capabilities as explained in the detailed descriptions following the implementation charts. It is quite possible that some of the DMS functional capabilities that are expected to require manpower effort for implementation will be already fully operational in the DMS obtained by MSC. In this case, the manpower loading for any fully implemented function should be deleted from the charts. This would reduce the required manpower for implementation of a fully operational DMS and data base.

The estimated manpower loading shown in these charts would not necessarily be all additional required manpower. The comprehensive functions provided by the DMS will undoubtedly eliminate the requirement for some data processing functions that are now being performed manually. The personnel involved in these manual data processing operations that are made unnecessary would be reassigned to the data base and DMS functional areas.

4.3 ESTIMATED IMPLEMENTATION MANPOWER REQUIREMENTS

The manpower required to install and modify a currently operating DMS will be much less than that required to write and implement a newly designed DMS. There will also be manpower requirement differences depending on the capabilities provided in the acquired system and the language in which it is written. Refer to the charts under Projected Schedule by Major Items for Data Base and DMS implementation manpower requirements.

An effective DMS will allow MSC to reduce the number of application programmers and analysts required. Through the use of simple, English type terminal language, many program requests which normally would be routed to a contractor's programming group will be done by a nontechnical person at a terminal. Thus contractor manpower needs will significantly reduce.

As functional modules of the DMS become operational, MSC personnel in the application areas being installed must be trained in the operation of the DMS on the computer. Training of personnel will be a recurring requirement since each application area would

require its own people trained to effectively utilize a terminal. The best approach would be to train them just before their application is made operational. Retraining will also be required as more capabilities are added to the system.

4.4 IMPLEMENTATION RECOMMENDATIONS

The most efficient approach in designing a DMS is to make it modular in nature. The DMS will basically consist of logic modules to define, create and maintain the data base, sort and merge data, retrieve data and report data. The DMS should be machine independent, not totally tied to one computer type. It should be written in a language which could be easily transferred to different computer hardware. This is necessary because technology is rapidly producing newer, more efficient data processing hardware which MSC may wish to install at some future date.

Logic modules to handle the needs of the various applications such as earth resources, logistics, procurement, etc., will be written separately from the DMS but will utilize the capabilities of the DMS in performing their functions. These applications modules will be programmed and installed according to the applications priority list. Building a DMS in this fashion will reduce conversion costs when new computer hardware is installed. It will also enable functional modules of the DMS to be used as they are installed and made operational. It will also serve to test and check out the DMS under an operational environment.

As discussed previously, manpower requirements will be less if a currently operational DMS is acquired and modified to fit MSC's needs. Acquiring a system will shorten the time necessary to install and check out the DMS. This will enable MSC to quickly utilize the capabilities of a DMS. Some systems are public domain, so it is quite probable MSC could install one of these systems simply for the cost of any modifications which would have to be made. Acquiring a currently operational DMS will shorten installation time, reduce manpower requirements, and reduce the overall cost of installing a DMS.

A careful analysis of data must be made to determine which data is to be placed into the data base. This analysis will consume a significant amount of time, but it is necessary. The analysis of data could begin before any programming is done on the DMS. In fact, some data analysis was performed for the pilot study which will be beneficial for the larger data analysis to construct the Center-wide data base.

The major emphasis in construction of the DMS is to first install the logic to define the data base. Next, the logic to create the data base must be installed. Most of the initial effort must be in these two areas. Preparing the logic modules to maintain the data base, sort data, retrieve data and report data could be done simultaneously. Once the logic to define and create the data base is installed, data files can be structured into the data base. Therefore, data analysis, coding and keypunching, if needed, could be done while the logic to define and create the data base is being written.

Once the data structuring logic is determined for the data base, the applications can be structured and placed into the data base. Some data may be structured directly from current tape files. Other data may need to be keypunched and entered from cards. Each application will require slightly different handling. The most advantageous structuring for each file must be determined. Some files may require an indexed sequential and/or hierarchical structure (see Figures 4-4 and 4-5) while others may best function utilizing a simple sequential type structure. Each file will have its own unique requirements.

Data files should be structured and placed in the data base according to the applications priority list. Earth resources should be considered for one of the first applications installed into the DMS. Their data storage needs are large and growing daily. A veritable explosion of data will be experienced in this area as a result of the Skylab Program. Coupled with this is a growing awareness by the public of the existence of this data. Their demands upon this data will grow very rapidly over the next few years. Flight scheduling should be considered high in priority. This is a very active area and has a critical need for DMS capabilities. Logistics and procurement applications must also have a high priority.

4.5 USER EDUCATION

A DMS requires an extensive user educational program. Users must be trained in the use of the DMS language, terminal language, terminal operations, data item dictionary, source data document index, DMS computer operations, and DMS batch operations. Users should receive the training they need to properly utilize the DMS as a tool to fulfill their job functions. Training manuals, classroom teaching, and private consultations with users must be provided.

- <u>DMS Language</u>. All analysts and programmers should receive training in the use of the DMS language. This will be used mainly for jobs oriented toward batch processing and will require a technical programming background. Through the use of the DMS's standard functional routines and the high level DMS language, applications systems and programs will be written more rapidly and thus be put into production more quickly.

- <u>Terminal Language</u>. Analysts, programmers and nontechnical persons who have a need to view data in the data base must be taught the use of the terminal language. Analysts and programmers could utilize terminals for system and program testing while the nontechnical users would utilize the terminals for quick answers to everyday procedural problems.

  This language should be simple, easy to learn, and of an English type language. It should be designed with prompting to assist a user with query input.

- <u>Terminal Operations</u>. Everyone who will be using terminals to query the data base will need instruction on how to operate the terminal hardware.

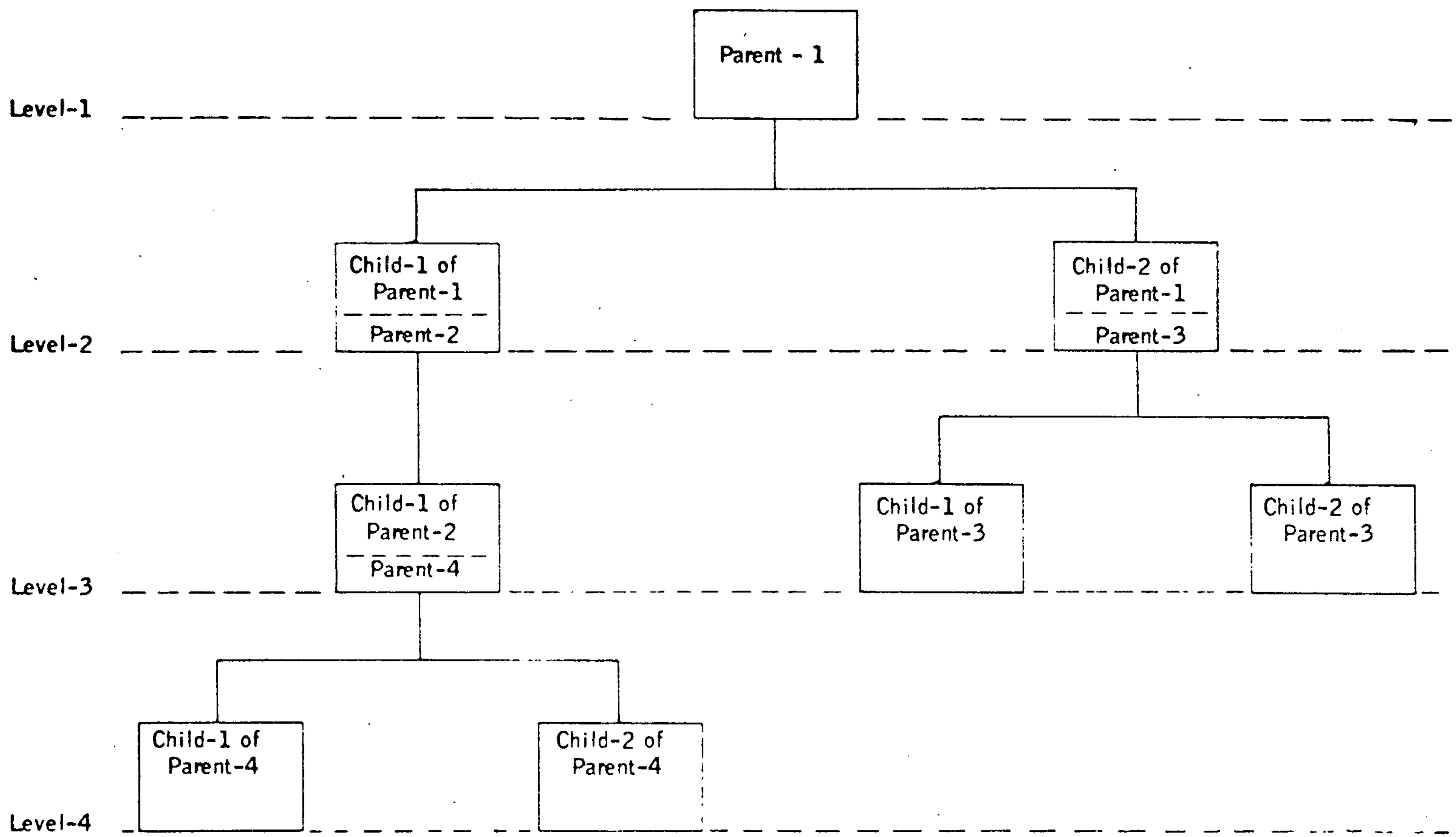


Figure 4-4. Example of Hierarchical Structure

INDEXED SEQUENTIAL STRUCTURE

Consider a payroll file with records structured as follows:

|—Record Key—|

Social Security Number	Organization Code	Name	Pay Rate	

Records in an indexed-sequential file would be arranged in ascending sequence by social security number (which is the record key). In addition the computer's operating system would create a table, each entry of which would contain a social security number and the cylinder and track address of the unique record on the disk.

When a record is to be accessed, the cylinder and track are obtained from the table for a particular record key. Then the read heads of the disk are directly positioned at the location of the record. The record is then read into the computer's core storage for processing.

The file does not have to be searched sequentially for the desired record. Any record on the file can be obtained directly.

Figure 4-5. Example of Indexed Sequential Structure

They need to know how to open a terminal for processing, the function of each key on the keyboard, and how to shut down a terminal. A manual explaining terminal operations should be placed at each terminal. Training in this area should include some "hands on" experience at the terminal itself.

- Data Item Dictionary. A data item dictionary is a necessary tool for all terminal and batch users of the DMS. They will need to know names applied to data, the data type (numeric or alphanumeric), the meaning of a piece of data (what it is used for), file name containing the data, record keys, etc. This knowledge is necessary to query data in the data base. A condensed version of the data item dictionary containing just the information necessary to make queries would be placed at each terminal.

- Data Source Document Index. There will be times when the DMS users will need to know the document from which certain data items are taken. These users should be taught how to use the data source document index to obtain this information when it is needed.

- DMS Computer Operations. Only computer operations personnel need to receive this training. A DMS with a Center-wide data base will require special handling in computer operations. Applications processing will take place in a real-time environment with simultaneous multi-job processing. This will result in more throughput from the computers and a much faster type of operation than in the past. Knowledgeable, alert operators will be required to ensure the most efficient utilization of computing hardware.

- DMS Batch Operations. Analysts and programmers will need to be thoroughly familiar with the DMS batch operations. Much of the applications systems output will come from the batch mode. Periodic reports, massive file updates, etc., will be done in the batch mode. The programmers will be writing the bulk of applications systems and will need this knowledge to more efficiently utilize the DMS and all of its inherent capabilities.

CSC

SECTION 5 - SUMMARY/RECOMMENDATIONS

SECTION 5 - SUMMARY/RECOMMENDATIONS

During the course of the study, it became apparent that techniques must be implemented which would make information processing at MSC more responsive to the users' requirements. A very effective solution to this problem is the implementation of a Data Management Supervisor (DMS), coupled with a comprehensive and well structured data base.

One of the prime advantages that accrues from the use of a DMS is the increase of capabilities offered the user in solving his information problems. Other advantages are in the areas of improved programming techniques, certain cost reductions, and improved processing efficiency.

5.1 DATA MANAGEMENT SUPERVISOR (DMS)

The advanced techniques of file management and retrieval made available by a DMS will be required by MSC to support the ever-increasing demand for information.

Standardized program routines, such as report formatting, data editing, data retrieval, and updating, invoked by the user will afford a system more oriented towards enhancing responsiveness to many different types of users. For the programming staff, ease and quickness of program maintenance and modification will be a significant factor.

Through the earth orbital program and its related scientific applications such as meteorology, earth resources, and earth physics, NASA could produce more pertinent data on our environment; the movement of the earth, land, and ice masses; and various weather models than heretofore imagined. This massive volume of data will require better than existing techniques for its maintenance and world-wide dissemination.

Flight scheduling is one of the most active areas at MSC. It will become even more active during the Skylab and Space Shuttle programs. The data files required to handle flight scheduling are large. When changes to the flight schedules are made, rapid access to the data on the files is necessary. One minor change could cascade into many changes throughout the entire schedule. Real-time, direct access to the data is especially mandatory while the missions are in progress.

The earth resources area has the potential of becoming one of MSC's largest and most active areas. Millions of items of data will be structured into the earth resources data set in the data base. This data is available to the general public and the demand by the public on this data will expand. Already large educational institutions, research foundations, and industry have made requests for this data.

All of these areas have a need for a DMS at the present time. This need will become even more critical as MSC efforts are phased out of the Apollo program into the Skylab program.

Some MSC groups such as earth resources, flight scheduling, and logistics have an urgent need for a DMS. Though the needs for a DMS are greater in some groups than in others, practically all the groups who were interviewed or who attended the demonstrations expressed a desire for MSC to install a DMS with a Center-wide data base. A few MSC groups even used the pilot DMS to do some of their production work.

A modular concept should be used in designing a DMS. Separate modules would be written to perform the various functions such as defining the data base, creating it, maintaining it, sorting data, retrieving data, and reporting data. Whenever changes to any area are required, a new module with the changes would replace the old module. Also the various MSC applications would be written as separate modules and would simply enter the DMS when necessary to utilize the capabilities provided by the DMS.

Timewise and costwise, a machine semi-independent language for the DMS is an extremely desirable design feature. The major functional modules of the DMS should be written in a high level, machine independent language such as COBOL. By doing this, a change in computers would require only minor modifications to the DMS. Refer to Appendix I for a detailed discussion of the DMS language.

5.2 PRACTICALLY STRUCTURED DATA BASE

It is of critical importance that the data sets within the data base are uniquely structured to take full advantage of the capabilities provided by the DMS in meeting users' requirements.

It would be unreasonable to assume that all data could be included in a data base. The capacity to store this volume of data would be unrealistic plus such a volume would downgrade the effectiveness of any system.

It would also be unreasonable to assume that all of the data which is stored could be structured and stored in the same manner. There is a difference between data and information; therefore structuring of files must be versatile enough to be highly responsive to many different types of information requirements.

By fully appreciating the importance of data base structuring and the effect it can have on the effectiveness and practicality of automated systems, MSC can progress more efficiently to the solution of its information sciences problems of the future.

5.3 MANAGEMENT INVOLVEMENT

In a major systems endeavor, it is imperative that management participate and involve themselves in its achievement and success. In organizations where the computer systems and the data base are regarded as major resources and as important tools in achieving goals, management must play a strong role. An automated system, to be an effective tool, requires a high degree of management involvement.

The prime management functions of control, scheduling, and decision making must be applied by MSC management throughout the phases of system development, implementation, and operation.

5.4 PROGRAMMING

A powerful programming language will be provided by the DMS. This language will enable programmers to quickly design and implement complex application systems that would normally take considerably longer to implement. This programming simplicity provided by the DMS results from the high level, functional type processing that can be utilized by a DMS programmer. To illustrate the power of the DMS language, an analogy could be made to the construction of a house. Most houses are built one piece at a time, but a house can also be prefabricated. This is the modular concept (see Figure 5-1). Through utilizing and combining highly advanced and efficient program modules, a DMS programmer can quickly design and implement very sophisticated and efficient application systems.

A great advantage provided by the DMS is the vast library of specialized program module routines that can be utilized by the DMS programmer. These specialized functional modules include routines such as file creation, file update, editing, encode/decode table lookup, statistical analysis, file sort and merge, data extraction, report formatting, report generation, graphics, etc.

There are also other important programming advantages provided by a DMS. Most of the MSC applications can be designed and oriented to utilize the DMS terminal capabilities. File maintenance and report generation can be quickly and easily performed utilizing the simple, English type terminal language provided by the DMS. This language, being specially designed for use by nontechnical persons, allows managers and staff assistants to rapidly update data and receive individually oriented, highly complex and meaningful reports.

Application program modifications and expansion can be made easily and quickly through utilizing the high level DMS programming language. The DMS programmer can invoke the DMS functional modules to perform the desired processing.

The DMS programmer could also include and call up program routines that were written in other programming languages, such as COBOL. This capability will allow utilization of currently existing MSC program modules and routines by merely specifying their name in a DMS program. Current MSC update and report generation application programs could therefore be used as is, except for the minor modifications that must be made to remove the processing of any redundant data. The DMS will also allow programmers to continue writing new application programs in other languages, such as COBOL, if so desired. It is recommended that programmers become familiar with the DMS language in order to take advantage of its much more powerful and comprehensive capabilities. Programs written in another language could, however, utilize the special function modules provided by the DMS.

Many programs will be written at terminals using the DMS terminal language. Once these are checked out and are producing successful output, they could be stored in the system libraries. They can then be executed by simply calling up the program name. The DMS will also contain a routine to permit a terminal user to type in program changes before a program is called up.

The DMS should generate program modules that have basically a common design format for the same DMS processing function (see Figure 5-1). The design format will be highly advanced and produce efficient processing routines. Thus for each specified DMS language processing function, the DMS programmer knows almost precisely the program logic that will be generated to perform that function. For example, the DMS sort function would always generate the same logic design for sort processing, regardless of the particular data file that is being sorted. Similarly, a file update will contain another logic design format that will be common to all file update routines.

The standardized program routines that will be generated by the DMS have many advantages. First, it allows each processing function to be designed to produce the most efficient processing. Second, it allows changes to be easily made to the generated programs. It also provides for simple, standardized documentation, since the same processing function would always generate basically the same program design logic. It also greatly facilitates modifications or expansions to programs written by another programmer.

5.5 PROCESSING EFFICIENCY

A DMS will provide MSC personnel with a real-time data access system which provides rapid retrieval of data from the data base. The retrieval time will depend on a number of factors such as query complexity, size of the data files being queried, search criteria, file structure, output requirements, other jobs running simultaneously in a multi-job environment, etc. Currently, most requests for computer runs require at least a 12-hour turnaround time which means a requestor's job can be processed overnight and returned to him the next morning. With a real-time data access system, each user will have immediate, direct access to the data in the data base.

Simplified program documentation will result for several important reasons. First, the DMS processing functions are highly modular. The DMS language provides a complete processing routine when a DMS function (and the few associated parameters) are specified (see Figure 5-1). For application system flow charts, the use of these DMS processing functions greatly simplifies the understanding of the entire application system.

Secondly, the DMS generates a standard program module for each DMS processing function specified by the user. For detailed flow chart documentation the same basic detailed logic design can therefore be used for any given DMS function, such as file update. The basic detailed logic flow charts for each different DMS function will be supplied to MSC users as part of the standard DMS documentation.

Most of the programs in the DMS applications modules will utilize the capabilities of the DMS. Since the documentation will have been written for the DMS, no new documentation

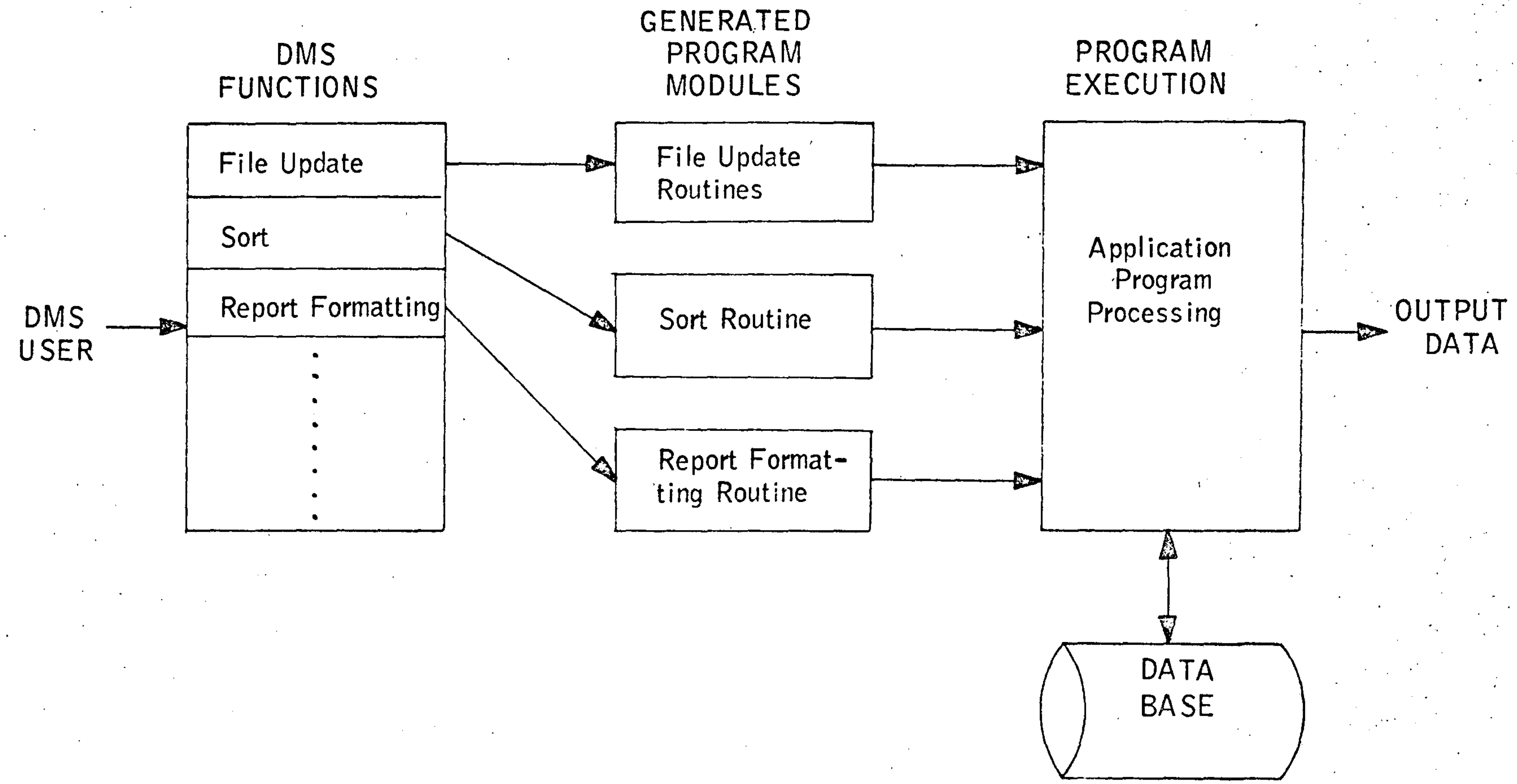


Figure 5-1. DMS Batch Processing

is required for those parts of the applications which utilize the DMS capabilities. This documentation will be standard in all programs. MSC's documentation standards will be more perfectly adhered to, and the time involved to prepare documentation will be shortened. Consequently, program utilization and understanding will improve as a result of standard documentation.

The modular and standardized design of the MSC application programs generated by the DMS will facilitate the integration of these applications into operational systems. Many functions required by applications systems will now be performed by the DMS. This includes such things as data editing and validation, file creation, data retrieval, report formatting, etc. So applications systems will now be much smaller after the DMS is installed, and programs will be written to utilize the capabilities of the DMS thus making the programs much smaller.

There must be time spent in analyzing the existing systems and data files to determine the best way to integrate the present environment into the DMS. Some systems could be combined with others, as could some data files.

Many of the files at MSC contain obsolete data and data which is also contained in other files. Obsolete data is information which is carried on current files but is never used. They were important items when the systems were developed but have ceased being functional or needed by the systems. This data could be completely eliminated, or could be saved as historical data if a potential need for it would exist at some future date. Only currently active data should be structured into the data base.

Some items exist on many different MSC application data files. This redundancy of data frequently results in these items having different values and contents in the various application data files throughout MSC. Most of these items need only appear once in the data base. Thus the redundancy of data would be greatly reduced.

5.6 USER BENEFITS

Analysis has shown that numerous files and redundant data in other files will be eliminated by the implementation of a common data base. This will result in a reduction of application programs that perform the same functions. The overall effect will be an appreciable reduction in duplicate software activities.

The design and construction of the data base will aid the various MSC groups in increased communications and coordinated activities. Proprietary rights to a group's data will virtually disappear unless the data requires security protection.

The expanded capabilities can be categorized into three broad areas; real-time processing, control of applications and data, and more efficient utilization of hardware and software.

Real-time processing provides a multitude of expanded capabilities, the most important being the man/machine interaction via a remote or local terminal.

MSC management, through having immediate access to comprehensive data concerning many facets of MSC activities will increase management visibility of the many MSC efforts and activities.

Once the DMS is installed MSC managers will no longer be required to wait from 12 to 24 hours for turnaround on their computer runs. The DMS will provide them with immediate, direct access to the data base.

It is of prime importance to MSC that any classified and sensitive data be protected from unauthorized access. Data access security protection will be one of the first DMS functional capabilities implemented. This will ensure that data security protection will be provided before any functional portions of the DMS are released for MSC utilization.

The automatic scheduling of production applications will be another significant capability provided for MSC. The operational schedule of execution for MSC applications could be specified to the DMS. Special override conditions would also be provided. This capability would be of considerable assistance to computer operations in the scheduling of weekly, monthly and year-end computer runs.

5.7 COST

Greater throughput per computer dollar will result from the installation of a DMS. The many data structuring techniques provided by the DMS will reduce the amount of time to retrieve data, thus allowing computer applications to be processed much more rapidly. Reduced processing time means reduced costs.

It is very difficult to estimate the dollars saved by providing real-time access to data. In the past managers have had to wait 12 to 24 hours, or even longer at times, for computer run results. In many cases the activities of many people were curtailed or greatly hindered by the wait. This is especially true of programmers who have to wait for turnaround on program tests.

Costs are greatly reduced through utilization of the simplified high level programming capabilities provided by the system. Costs will also be reduced through standard procedures for computer operations for all phases of the DMS comprehensive activities. Another important cost savings will result from the standard program logic modules generated by the DMS. Program standardization also greatly simplifies program documentation since each generated logic module will have the same basic logic design format for any given system function.

The key to reduced program maintenance costs is the ease of modifications that can be made at two different program levels. At the highest level, using the simple yet powerful DMS programming language, program modifications and expansion can be easily implemented. At another program level, using the standardized logic modules generated by the DMS, program maintenance is also facilitated. This results largely from the fact that the basic logic design format would be known for each of the generated MSC

applications functions, (e.g., sorting or report generation). Also important is the advantage of having the generated application programs written in a high level language, such as COBOL. The high level language greatly facilitiates program modifications and expansion at the generated application program level.

Having more powerful tools to work with, the productivity of a programmer utilizing DMS capabilities will greatly increase. In addition, through the use of high level languages and with standardized programming techniques utilized, there will be little difficulty for a programmer to modify or expand programs designed and written by other programmers. This program transferability previously has been a serious problem throughout the computing industry.

An MSC application module (e.g., logistics, capitalized equipment) may be developed and implemented in a much shorter time through utilizing the powerful DMS capabilities. The cost savings to MSC is therefore not only in the reduced amount of application program design, implementation, and maintenance, but also in the reduced lead time required for new application implementation.

MSC has an enormous number of application data files which require file maintenance programs in order to keep the data current and valid in these files. As shown above, the powerful DMS language capabilities greatly reduce programming time and effort. A tremendous file maintenance cost savings will be achieved for MSC through utilization of the DMS programming languages. The size of the data files and the number of the application data files will also be reduced since redundant data could be minimized in the MSC data base.

The major portions of the DMS itself will be written in a high level language such as COBOL. This high level language programming of the DMS will allow the DMS (and MSC applications programs written in high level languages) to be transferred from one computer to another with only minor modifications required and will result in a tremendous cost savings to MSC.

Similarly, if a different operating system for the computer were released by the computer manufacturer and installed at MSC, there would be relatively little impact on the DMS system modules or on the MSC application programs utilizing the DMS functions. This advantage results from the modular design and high level language programming capabilities utilized by the DMS.

There will be an initial cost for implementation of the DMS, data base, and hardware configurations. This cost, however, will be minimized by the considerable long range savings provided when the DMS is functionally operational. The powerful and comprehensive additional data processing capabilities provided by the DMS will also offset the initial cost.

Initial training of MSC personnel will be required to utilize the DMS functional capabilities. This training will be needed primarily in the use of the terminal language and the high level DMS language. Due to the simplicity of these languages and the use of prompting, only a small amount of training will be required to enable MSC personnel to use the system.

5.8 SUMMARY

In summary, it is recommended that NASA MSC:

- Implement in a time frame of one year or less a Data Management System that either embodies the required capabilities as set forth in this study, or may easily be enhanced to include the required capabilities.
- Establish an applications/data file priority list for implementation that is compatible with lead times of known MSC missions.
- Immediately start analyzing and structuring data sets which realistically reflect MSC requirements.
- Develop a Center-wide data element and function dictionary which would be used as a management tool to control system quality, and as a user tool to obtain maximum responsiveness.
- Approve and implement acquisition of long lead hardware required to support the DMS and data base.
- Develop an MSC wide management plan that will have the effect of recognizing the data base as an on-going MSC resource, and thereby delegate its control to team management decisions rather than individuals and unilateral actions.
- Select a contractor thoroughly familiar with commercial-type processing, all aspects of DMS logic, and complex and varied data base construction to implement the MSC DMS. Contractor familiarity and understanding of user requirements are essential factors to be considered.

CSC

APPENDIX A - MSC PERSONAL INTERVIEWS

APPENDIX A - MSC PERSONAL INTERVIEWS

Mail Code	Division	Persons Interviewed
BB	Institutional Resources and Procurement	William P. Kelly, Jakey Wood, Parker Carroll
BB12	Institutional Resources and Procurement	Bob Soens, D. R. Hendrickson
BD22	Research and Development Systems	Dave Friis
BD23	Research and Development Systems	Clyde Lourimore, Rudolph Willman
BE	Management Analysis and University Programs	Leslie Sullivan, Bill Larsen, Charlie Buckel
BF	Logistics	Jim Frizzell, George MacDougall, Bob Boyd, Bill Bennett, Bill Calhoun
BM	Management Services	Earl Rubinstein, Stan Jacobsen, Roy Magin, Al Bradley
BM2	Management Services	Harold Davis, Carol Childs, Pete Fox
BN6	Engineering	Ross F. Jarvis
BP23	Personnel	Burney Goodwin
BR6	Financial Management	Tom Stanley, Bill Grayburn
CC4	Aircraft Operations	Charles Haines, Vern Swenson, Al King
CF6	Flight Crew Support	Frank Hughes, B. Bahman
DC	Preventive Medicine	Dr. Walter Kemmerer
DE3	Biomedical Technology	Frank Michelli, Dr. Edward Moseley, Dr. Clarence Jernigan
EA7	Engineering and Development	Paul Brandenberger
EB4	Information Systems	Roger Hodgkins

CSC

Mail Code	Division	Persons Interviewed
EC1	Crew Systems	Tom Strickler, Edward Smylie, Hugh Fleming, Don Perry
EE	Telemetry and Communications Systems	Tom Fleming
EE2	Telemetry and Communications Systems	Saverio Guadiano
EG7	Guidance and Control	Chuck Finch
EL2	Space Environment Test	David Billingsley, Bill Taylor, Jim Anderson
ES2	Structures and Mechanics	Ray Nieder, Jim Johnson, Ed Jung
ES34	Structures and Mechanics	John Orsag
EX2	Engineering Analysis	Joe Gamble, Ray Nelson
FC	Flight Control	Bill Platt
FC1	Flight Control	C. S. Howard
FD4	Computation and Analysis	Don Hay, Norris Taylor
FM13	Mission Planning and Analysis	Dick Parten, Mike Collins, Jim Grogin
FS	Flight Support	Maynard Huntley, Sam Ruple
FS2	Flight Support	Kenneth Allen, Larue Burbank
FS6	Flight Support	Jack Garman
HC	Advanced Program Planning	W. L. Davidson, Jim Arnold
JB2	Program Resources	Bob Linberger
JB5	Program Resources	Humboldt Mandell, Bill Roberts, Howard Renfro, Garland Bauch, Ralph Schomburg, Ronnie Lewis
JC8	Contracts	Harry Watkins

CSC

Mail Code	Division	Persons Interviewed
LV	Space Shuttle Program	James Medack
NA2	Reliability and Quality Assurance	Karl Sperber
NS	Standards Engineering	Jim Donnell, Merle Schwartz, John Hook
PP	Program Control	Don Haulbrook
PT3	Test	Gallaway Foster, Bill Kelley, Jim Gibbons
TA	Science and Applications	Richard Wright
TF7	Earth Observations	Jerry Carney, Sid Whitley, Dean Britton
TJ	Mapping Sciences Laboratory	Bob Musgrove, Andrew Patterson
TL3	Lunar Receiving Laboratory	Ken Suit, Dave White, Dan Anderson
TN7	Lunar and Earth Sciences	Dr. Jeff Warner

APPENDIX B - PERSONAL INTERVIEW STRUCTURED QUESTIONS

APPENDIX B - PERSONAL INTERVIEW STRUCTURED QUESTIONS

1. Does user want terminal and batch capability for the future system?

   a. Batch only

   b. Terminal only

   c. Both

2. Does user require the capability to update his data on-line? Does he then require immediate capability to view the results of his input?

3. Are there requirements for inter-file interface?

4. Does the user have a requirement that demands the future system to provide the capability such that when data in one file is updated, other files containing that item, or items, can be updated automatically?

5. a. Does user require security protection?

   b. What security level is required? Field, record, or file?

6. Does user have requirements that demand variable length fields?

7. Does the user require the capability to have synonyms?

8. Does user have requirements that demand use of boolean connections?

9. Does user require program to provide any statistical analysis of data?

10. Does user have requirement for program to provide conditional processing?

11. Does user require capability to vary the output report format prior to processing, and the ability to display any item or items in a specified file?

12. Does user require ability to save a created display from terminal?

13. Does user require the capability to do a keyword search?

14. Does user require any graphics capability?

15. Does user need to publish a document and use program outputs as part or all of the source?

16. Does user require any simple arithmetic operations such as +, -, x, or ÷?

17. Is a hard copy capability needed at the terminal?

18. Is an audit trail needed?

19. Are mathematical function subroutines (trigonometrical, log, exponential, square root, etc.) needed by the user applications?

20. What terminal devices are wanted for the future system?

21. What volume of terminal processing per week is expected by the user applications?

22. How many persons in the user applications will be using the terminal?

23. What volume of batch processing per week is expected by the user applications?

24. What response time would be required for reports in batch mode?

25. What frequency of usage of program in batch and terminal mode would be expected?

26. Do users have standard input forms they are using for current needs?

CSC

APPENDIX C - PILOT STUDY DEMONSTRATIONS

APPENDIX C - PILOT STUDY DEMONSTRATIONS

Mail Code	Division	Attendees
AT	Advanced Studies	Sharon Henderson
BB12	Institutional Resources and Procurement	Bob Soens
BD22	Research and Development Systems	Dave Friis
BD23	Research and Development Systems	Clyde Louirmore
BF	Logistics	Bob Boyd
BF4	Logistics	Bill Bennett
BF9	Logistics	Bill Calhoun, Glen Keith
BL3	Photographic Technology Lab	John Salinas
BM	Management Services	Earl Rubenstein, Al Bradley
BM2	Management Services	Charles Grant, Harold Davis
BM24	Management Services	Frank Goodson
BM5	Management Services	Roy Magin, Stan Jacobsen, Helen Foley
BN8	Engineering	Carl Romero
BR6	Financial Management	Tom Stanley, Ray Kaufman, D. W. Sparkman
CF6	Flight Crew Support	Frank Hughes
CG	Crew Procedures	Jim Lewis
CG2	Crew Procedures	Bill Leverich, Tom Kaiser. M. E. Dement, Gail Steele, John Monroe, John Samouce, Bob Hahne

CSC

Mail Code	Division	Attendees
CG53	Crew Procedures	Mike Gremillion, John Cotter, Gene Gentry
EA7	Engineering and Development	Paul Brandenberger
EB4	Information Systems	Roger Hodgkins
EB5	Information Systems	Emmett Shepard
EC1	Crew Systems	Hugh Fleming, Edward Smylie
EC4	Crew Systems	Joe Trombley
EC12	Crew Systems	Don Perry
EE	Telemetry and Communications Systems	Tom Fleming
EG2	Guidance and Control	Carey Lively
EG7	Guidance and Control	Chuck Finch
ES2	Structures and Mechanics	Ray Nieder
ES34	Structures and Mechanics	John Orsag
EX	Engineering Analysis	Bill Moseley
FA	Flight Operations	L. C. Dunseith, Bob Driver, Bob Ernull, H. W. Tindall, John Frere, Jr.
FC1	Flight Control	C. S. Howard, Charlie Harlon
FD	Computation and Analysis	Ralph Everrett, Don Lloff
FD3	Computation and Analysis	M. Cunningham
FD4	Computation and Analysis	D. Hay, Norris Taylor
FD7	Computation and Analysis	Art Hambleton

CSC

Mail Code	Division	Attendees
FD81	Computation and Analysis	Boyd Jackson
FD87	Computation and Analysis	Wilby Ward
FM6	Mission Planning and Analysis	Ernie Fridge, Mary Ann Goodwin, Bill Sullivan
FM13	Mission Planning and Analysis	Dick Parten, Mike Collins, Jim Grogan, Ray Hischke, Dick Simms
FS	Flight Support	Maynard Huntley, Matt Quinn, James Stokes, Jerry Milhorn
FS4	Flight Support	Jacqueline Gregan
FS5	Flight Support	Larry Dungan
FS6	Flight Support	Jack Garman, Jim Martin
HA	Advanced Missions Program	Jim Tomberlin
JB2	Program Resources	Bob Linberger
JC2	Contracts	Jim Crane
ND	Quality Assurance	Ray Heiskala
ND3	Quality Assurance	Max Callison
ND5	Quality Assurance	John Fisher, Jack Cohen
ND33	Quality Assurance	Tom Matuszewski
NS	Standards Engineering	Jim Donnell, Merle Schwartz, Bill Harvey, Johnny Arnaud
TF	Earth Observation	Edward Zeitler
TJ	Mapping Sciences Laboratory	Bob Musgrove
	NASA Headquarters	Verl Huff, Gene Lokey

CSC

APPENDIX D - DELIVERABLE ITEMS HIGHLIGHTS

APPENDIX D - DELIVERABLE ITEMS HIGHLIGHTS

D.1 STUDY PLAN

CSC's plan to accomplish all work, including a schedule of agreed upon intermediate milestone events and manpower estimates was presented to MSC. The milestone schedule is shown below.

Milestone	Start Date	Target Completion Date	Actual Completion Date
Initial Briefing		8-14-70	8-7-70
Data Base Study Plan	8-3-70	8-14-70	8-14-70
Structured Interviews	8-15-70	10-2-70	9-25-70
Required Capabilities Analysis	9-9-70	10-9-70	10-1-70
Identify Candidate Users	9-21-70	10-9-70	10-6-70
Recommend Pilot Users	10-1-70	10-9-70	10-6-70
Program Changes to DMS	10-1-70	12-1-70	11-30-70
Provide DMS Sample Data	11-1-70	12-1-70	11-30-70
Data Base Structure Recommendation	11-1-70	12-1-70	11-30-70
Midterm Report		3-1-71	3-1-71
Analysis for Future System	11-9-70	6-11-71	6-11-71
Pilot System & Pilot User Recommendation	1-14-71	7-9-71	7-9-71
Recommend Updates to Documentation	1-4-71	7-9-71	7-9-71
User Indoctrination	11-9-70	7-30-71	7-30-71
Final Report & Presentation		7-30-71	7-29-71
Executive Summary		7-30-71	7-29-71
Monthly Progress Report	1st of each Month	10th of each Month	

D.2 DESIRABLE CAPABILITIES OF THE PILOT DMS

CSC, after analyzing MSC data base interests and requirements, determined the software and hardware capabilities required by the pilot DMS. CSC organized and categorized these required capabilities into a comprehensive report for MSC personnel. The report titled, "Desirable Capabilities of the Pilot Data Management System for the MSC Data Base, October 1, 1970," was presented to MSC on October 1, 1970.

D.3 CANDIDATE DATA FILES AND RECOMMENDED DATA FILES

After completing initial structured interviews with MSC personnel, CSC analyzed each application's data as a candidate for the pilot DMS. From the identified candidate MSC users, CSC then recommended for utilization with the pilot DMS those MSC user applications which best represented a good cross-section sampling of different types of MSC data.

The report titled, "Candidate Data Files and Recommended Data Files for the MSC Data Base, October 6, 1970," was presented to MSC by CSC.

D.4 STUDY PLAN UPDATE

In concurrence with the technical monitor, the delivery date for the following items was changed to December 1, 1970.

- Required Changes to the Pilot DMS
- Sample Data for Implementation
- Data Base Structure Recommendations

The reasons for the schedule change were:

- The selection of the pilot DMS by MSC was not made known to CSC until October 29, 1970.
- A four (4) week period following the selection date was required by CSC in order to provide MSC with the above three (3) items.
- This period also included follow-up interviews with the MSC organizations whose application data had been selected for the pilot DMS.

D.5 RECOMMENDED CHANGES TO THE PILOT DMS

CSC analysts made a comprehensive study of NIPS and HYPERTEXT, the systems that together comprised the DMS that was selected for the pilot study. All of the

MSC candidate users were interviewed to determine their specific requirements for a DMS. Their requirements were then compared to the capabilities provided by NIPS and HYPERTEXT. From this comparison, CSC compiled a list of DMS capabilities that are required by the MSC users, but were not provided by the pilot DMS.

Recommended changes to the pilot DMS were then organized and categorized by the DMS function to which they related. CSC recognized that all of the recommended changes to the pilot DMS could not be implemented in the relatively short time period allocated for implementation. The recommended changes were therefore listed in the order of their importance to the MSC users of the pilot DMS.

CSC presented to MSC the report titled, "Recommended Changes to the Pilot Data Management System, November 30, 1970."

D.6 FILE DESCRIPTIONS, SAMPLE DATA, AND DATA STRUCTURE RECOMMENDATIONS FOR THE PILOT DMS

After the pilot user applications had been chosen, sample data was collected that could be used as input to the selected application programs. The sample data chosen for usage was actual data that had been utilized previously with operational user application programs and typical representative data that will be utilized in the newly designed user application system. This sample data also contained a cross-section of representative data for the pilot user applications that had been selected.

CSC prepared file descriptions for the MSC user application files that would be in the MSC pilot DMS data base. The file descriptions explained the record formats of the user files as they currently exist for the UNIVAC 1108 computer. Each file description contained the following information: field number, field character position, number of characters, field picture (numeric or alphanumeric), field name, field contents and field definition.

File descriptions were prepared for the following thirteen (13) user application files:

- Labor Distribution
- Accounting
- Procurement 497
- RMD Labor
- Contract Status Report
- Budgetary Control

- Flight Control Status
- Standards Engineering Information
- Capitalized Equipment
- Graphic Arts
- Catalog Index
- Earth Resources Research Data Facility R&D
- Advanced Spacecraft Cost Analysis

The file record formats and data were not then available for three (3) of the files selected for the pilot DMS. The data base record formats for these files were therefore determined and designed by CSC. The file descriptions for these files were prepared by CSC as a supplement:

- Lunar Sample Natural Language Information
- Skylab Program Operational Data Book (HYPERTEXT)
- Statements of Work (HYPERTEXT)

It was necessary to modify the format of the selected user application data on seven (7) of the MSC user data files in order to implement the data into the pilot DMS data base.

D.7 DISPLAY AND OUTPUT FORMATS FOR THE MSC USER FILES

CSC presented to MSC the document titled, "Display and Output Formats for the Pilot DMS User Files, December 11, 1970." This document contained sample batch output report pages and report formats for the pilot DMS user files. The report formats provided were, for the most part, for typical reports that are currently being produced for the MSC user applications. A few of the reports were specially formatted by CSC to display all of the data fields contained in the user application files.

D.8 SUPPLEMENT TO FILE DESCRIPTIONS AND OUTPUT FORMATS

CSC provided file descriptions, sample data and output report formats for the following additional MSC pilot DMS user applications:

- Lunar Samples Natural Languages Information

- Skylab Program Operational Data Book
- Statements of Work

CSC presented to MSC the report titled, "Supplement 1 to File Descriptions, Sample Data and Output Formats for the Pilot Data Management System, December 22, 1970."

D.9 MONTHLY PROGRESS REPORTS

Each month, CSC provided to NASA a technical report that described the status of each major task in the data base study project. The progress that was achieved within each section of the major tasks during that month was explained in the technical report. The manpower hours expended by CSC were shown by calendar month and as a cumulative total.

The monthly progress report also provided the status of the coordination tasks with the implementing contractor. Computer time utilized in exercising and evaluating the pilot DMS was also shown for each month.

D.10 MID-TERM REPORT

This report described the CSC activities, deliverable and special documents, and meetings held during the first seven months of the data base study project. The purpose, plans and achievements of the study were also described in the mid-term report.

D.11 FINAL REPORT

This report describes the required and desirable functional DMS capabilities for the MSC future system. Recommendations concerning implementation of the MSC data base and the DMS are also presented. The report also describes the activities and the highlights of the entire data base study.

CSC

APPENDIX E - SPECIAL REPORTS AND DOCUMENTS HIGHLIGHTS

APPENDIX E - SPECIAL REPORTS AND DOCUMENTS HIGHLIGHTS

E.1 DATA BASE REQUIREMENTS QUESTIONNAIRE

CSC developed a set of carefully planned questions designed to collect information of uniform quality and to permit the separation of fact from opinion. This Data Base Requirements Questionnaire was sent to all interested MSC groups prior to the intervies. The purpose of the questionnaire was to obtain detailed information about the present and future planned data processing activities of each group and to determine their data base on-line terminal, random access requirements. A copy of the Data Base Requirements Questionnaire is contained in MSC memorandum 70-FS52-129.

E.2 CANDIDATE FILES FOR MSC DATA BASE - PRELIMINARY DRAFT

CSC formulated a list of potential MSC user applications for the pilot DMS. This MSC user application was presented to MSC in the report, "Candidate Files for MSC Data Base, Preliminary Draft, September 17, 1970".

Each MSC user application on the list was analyzed by CSC as to their acceptability as a candidate user of the pilot DMS.

E.3 SAMPLE QUESTIONS FOR MSC USERS OF PILOT AND FUTURE DMS

CSC designed 26 questions concerning MSC user requirements for both the pilot DMS and the MSC future DMS. The questions were stated in the CSC document, "Sample Questions Need Answering From Users For Both Pilot And Future Systems, October 14, 1970; Revised November 6, 1970".

These 26 questions were asked in follow-up interviews by CSC to each of the MSC users whose applications were selected for utilization with the pilot DMS. These questions covered the important and basic capabilities that should be provided by a Data Management System. During the follow-up interviews, the MSC users replied to whether or not each of the DMS capabilities was actually required by their application. The questions are shown in Appendix B.

E.4 MSC DIVISIONS INTERESTED IN THE DATA BASE STUDY

CSC formulated a list of all MSC divisions that had displayed interest in the data base study. CSC presented to MSC the report, "MSC Divisions Interested in the Data Base Study, October 16, 1970". In this report, the divisions and mail codes were shown for all the MSC user groups that were interviewed by CSC. The report also indicated the divisions and mail codes of MSC groups who were interested in the study but had not requested to be interviewed at that time.

E.5 NIPS/USABAAR DMS CAPABILITIES COMPARISON

A comparison of NIPS with USABAAR DMS was made in respect to 16 major capabilities that should be provided by a data management system. The report, "NIPS/USABAAR DMS Capabilities Comparison, October 21, 1970", was given to MSC by CSC.

E.6 PILOT DMS PROBLEM AREA ANALYSIS

In the report, "Recommended Changes to the Pilot Data Management System, November 30, 1970", CSC outlined 18 necessary changes to overvome the system problems and deficiencies in NIPS.

CSC analyzed these NIPS problems and determined ways to circumvent the problems and to simulate the DMS capabilities.

The NIPS problem solutions were described in the report, "Pilot DMS Problem Areas Analysis, December 11, 1970", which was presented to MSC by CSC.

E.7 ANSWERS TO IBM'S QUESTIONS CONCERNING USER FILE DESCRIPTIONS

At the December 22, 1970, CSC/IBM Meeting, IBM asked CSC questions concerning the MSC user file descriptions and report formats for the pilot DMS. CSC performed the necessary research to obtain the required information and then presented to IBM the report titled, "Answers to IBM's Questions Concerning User Application File Descriptions and Output Reports, January 4, 1971".

E.8 PILOT DMS PROBLEM ITEM REPORT

CSC analysts designed and executed many comprehensive system tests to evaluate the pilot DMS. During these system tests, some pilot DMS system problems were encountered by CSC. Five of these pilot DMS system problems were described in the report titled, "Pilot DMS Problem Item Report, January 4, 1971", which was presented to MSC by CSC.

E.9 NIPS DEMONSTRABLE DMS CAPABILITIES

CSC analysts spent many hours at the IBM 2250 and 2260 terminals executing comprehensive system tests that CSC had designed for the pilot DMS. A major purpose of these system tests was to evaluate the pilot DMS in relation to the DMS capabilities required by the MSC users. The results of these system tests indicated the current status of the DMS capabilities of NIPS that could be demonstrated. These system test results were highlighted in the report titled, "NIPS Demonstrable DMS Capabilities, January 29, 1971", which was presented to MSC by CSC.

APPENDIX F - MEETINGS, BRIEFINGS, AND CONFERENCES

APPENDIX F - MEETINGS, BRIEFINGS, AND CONFERENCES

F.1 DATA BASE STUDY BRIEFING

In order to determine MSC requirements for a future automated data management system which will support both technical and management personnel, each directorate and division of MSC was contacted by CSC and informed about the study, the purpose of the study and a general meeting that would be held concerning the study.

The Data Base Requirements Study general meeting was held August 7, 1970. Mr. Byron Huffman of CSC and Mr. B. L. Brady, technical monitor for this study from the Flight Support Division, gave a briefing about the data base study and presented the plans, procedures and schedules for the study. Mr. Huffman stated that a pilot Data Management System (DMS) would be selected that would best meet the requirements of the MSC data base users. Mr. Huffman explained that the pilot DMS would probably not satisfy the complete data processing requirements of all MSC users. He stated that one purpose of this study by CSC is to determine those capabilities required by MSC that could not be contained within the scope of a pilot DMS. He also further explained the role of CSC in determining from interested users their respective requirements for the future DMS, that is, type of data, display formats for report generation, terminal devices required, applications, etc.

A complete description of the August 7 briefing is contained in memorandum 70-FS52-126, Participation in a Center-Wide Data Base Requirements Study.

F.2 CSC/IBM MEETINGS

Seven (7) Technical meetings between CSC and IBM occurred during December, 1970, and January, 1971. The primary purpose of these meetings was to highlight, discuss and make plans for resolving any important technical or interface problems concerning the pilot DMS.

Numerous informal meetings and discussions have also occurred between CSC and IBM during the data base study.

F.3 USABAAR DMS DEMONSTRATION

The following persons were at Fort Rucker, Alabama, on September 29 and 30, 1970, for a demonstration of the USABAAR DMS capabilities:

- Shirley Hinson (MSC)
- Jack Adams (IBM)
- Mike Felix (IBM)

- Cleon Smith (IBM)
- Byron Huffman (CSC)

F.4 CANDIDATE AND RECOMMENDED USERS REVIEW MEETING

A meeting was held with Mr. Jim Stokes, Chief of Flight Software Branch of the Flight Support Division, on October 7, 1970. At this meeting, the MSC candidate users and recommended users of the pilot DMS were reviewed.

The major functions performed by these user applications were discussed and the related activities between the user applications were pointed out by CSC.

F.5 MSC/CSC MEETINGS

Each week, periodically, CSC reviewed the significant items, work schedules and expected completion dates for the tasks in the study with the MSC technical monitor for the data base study.

F.6 EARTH RESOURCES MEETINGS

A technical meeting was held on February 25 with Earth Resources and IBM personnel in order for CSC to explain the technical procedures for the implementing of the Earth Resources Research Data Facility R&D Text and Table Files into the pilot DMS data base. CSC described the design, procedures and programs' specifications for correlating and combining these files into one composite, structured data file. Mr. Frank Goodson indicated that several encode/decode and synonym tables would be required by Earth Resources for an expanded terminal capability. A significant effort was expended by CSC in developing and designing the best procedures to correlate the data from these two files.

On March 2, 1970, Mr. Frank Goodson demonstrated and explained the present Earth Resources catalog, retrieval, and display capabilities and procedures.

A meeting was held on April 5, 1971, to discuss the plans of the Earth Resources group in evaluating and utilizing the terminal capabilities of the Data Management Systems available to MSC.

F.7 MASSIVE DATA STORAGE PRESENTATION

A new state-of-the-art technique for providing massive on-line data storage was presented on May 7, 1971, by the AMPEX Corporation. This new system design for data base storage is the Terabit Memory System (TBM). The TBM system provides random access to 400 billion data bytes which is equivalent to the capacity of 30,000 computer tpes (800 BPI). TBM utilizes two inch video tape with high data packing and an extremely fast tape search speed of 1000 inches per second.

APPENDIX G - SPECIAL TASKS PERFORMED BY CSC

APPENDIX G - SPECIAL TASKS PERFORMED BY CSC

G.1 CONVERSION OF MSC USER DATA FILES

The pilot DMS user data was written by the MSC users in UNIVAC 1108 format. In order for the data to be entered into the data base for the pilot DMS, the UNIVAC 1108 data files had to be converted to an IBM 360 readable format. When the user data files were converted, however, seven (7) of these files contained binary numeric or signed fields which would not convert properly.

MSC requested CSC to perform the conversion for these data files. CSC was happy to comply with this request and designed, wrote and checked out seven (7) COBOL computer programs that were required for the data conversion. These data files were then successfully converted by CSC.

MSC user file description revisions to seven (7) of the pilot DMS user data file descriptions were designed and documented by CSC analysts. These revisions were necessary as a result of the data format changes resulting from the conversion of the user data files from UNIVAC 1108 format to IBM 360 format. The actual data files that were converted for the IBM 360 computer, and the revised, complete file descriptions were given by CSC to the implementing contractor for the following files:

- Labor Distribution
- Accounting
- Procurement 497
- RMD
- Contract Status Report
- Budgetary Control
- Capitalized Equipment

G.2 EDITING OF PILOT DMS DATA

In three (3) of the above files erroneous data existed. Also, some of the financial data fields in these files contained amounts exceeding twenty-one (21) million dollars, which when processed, caused many system failures in NIPS. CSC, therefore, reconverted these files in order to eliminate both the erroneous data and the data that exceeded the processing capabilities of NIPS. In order to prevent these system failures, any financial data that exceeded one (1) million dollars was eliminated from the user files.

The following files were reconverted by CSC:

- Procurement 497
- Contract Status Report
- Budgetary Control

G.3 TERMINAL USER CATALOGED ENTRIES

NIPS did not provide the capability for a terminal user to specify the cataloging (saving) of his terminal entry commands. In order to simulate this capability, it was necessary to precode some typical MSC terminal user functions and operations and then catalog them in the batch mode.

MSC requested CSC to write these typical MSC user entry functions and operations. CSC complied with this request and designed and coded two (2) complete 'programs' of typical MSC user terminal entries for each MSC user application of the pilot DMS.

G.4 PILOT DMS TRAINING SESSIONS

Special assistance was provided by CSC to the Earth Resources group in structuring queries to be used in extracting data from the pilot DMS data base. CSC provided computer time and terminal assistance to Earth Resources on many occasions to perform their information retrieval. One of the queries concerned some coastline mapping data requested from the office of the President of the United States. Training sessions were also provided to MSC and contractor personnel in utilizing the HYPERTEXT terminal data editing and formatting capabilities.

CSC

APPENDIX H - TERMINAL USER LANGUAGE

APPENDIX H - TERMINAL USER LANGUAGE

H.1 SIMPLICITY OF USE

The terminal language of the DMS must be oriented toward the non-technical users. The terminal language must be easy to learn and simple to use.

When processing specifications are required from a terminal user, the DMS should request this information by asking questions of the terminal user. This is called "prompting" the user. The terminal user would then enter in the processing specifications for the operations he wants performed. A simple conversational mode language would be provided for the terminal user.

Detailed error diagnostics should be displayed by the terminal language whenever the terminal user enters invalid information. Simple procedures to correct any user error should also be provided so that the user will not be required to reenter the complete query.

H.2 ENGLISH LANGUAGE ENTRIES

The terminal user language should normally consist of short English statements. When multiple item names are required, the terminal user should be allowed to enter these names in any user desired order, separating them by commas. A minimal amount of information should be required from the terminal user.

H.3 TERMINAL USER OPERATIONS

The terminal user should be able to display any data in the data base that he has been authorized to access. He should also be able to create, modify and insert data into data sets in the data base for which he has been grated read/write authorization. Unauthorized users would be prohibited from performing these operations.

A user password should be assigned to each terminal user. Associated with each user password would be the display and update data authorizations for that user.

A SORT operation should be available to the terminal user. This would allow him to search, retrieve, display and update data in any user specified data sequence.

A terminal user should be able to save and later reuse any query or file update operation.

A terminal user should be able to obtain a hardcopy (printed, typewritten, etc.) of any data that was displayed.

The DMS must therefore provide the capability for a terminal user to perform the following operations:

- File Create and Update
- Sort
- Catalog/Recall of User Operations
- Query
- Display of Data
- Hardcopy of Displayed Data

A detailed description of these functional capabilities is provided in Section 3 under Required DMS Functional Capabilities.

CSC

APPENDIX I - DMS LANGUAGE

APPENDIX I - DMS LANGUAGE

I.1 DMS BATCH PROCESSOR

- Modification and Expansion Simplicity - The primary requirement for the DMS Batch Processor is that the functional modules of the DMS be easy to modify and expand. To facilitate making DMS program modifications and enhancements, the Batch Processor modules should be written in a high level language, such as COBOL. High level language programs are considerably easier to modify and expand than assembly language programs. This important advantage of program modification expansion simplicity provided by a high level language is certainly very significant.

- Computer Transferability - The DMS must be able to functionally operate on other computers by making only minor modifications to the DMS. This capability would exist for the Batch Processor if it were written in a high level language. Assume for example, that MSC had implemented a DMS utilizing the IBM 360 computer and there was a requirement to implement this same DMS for the UNIVAC 1108 computer at the Marshall Space Flight Center. If a high level language were utilized for the DMS, only minor modifications would be required to accomplish this important task.

- Batch Processing Efficiency Considerations - The processing performed by programs written in a high level language is sometimes slightly less efficient than the processing performed by assembly language programs. A certain tradeoff to gain important DMS advantages must be offset by a minor disadvantage of a relatively insignficant increase in DMS processing time through utilizing a high level language. Normally a high degree of processing efficiency is not a critically important requirement for a Batch Processor. The important DMS modification, expansion and transferability advantages provided by a high level language make the very small difference in the Batch Processor run time appear insignificant.

  For these reasons, pure assembly language or even assembly language with macros, should be avoided or used sparingly by the Batch Processor.

I.2 DMS TERMINAL PROCESSOR

- Terminal Processing Efficiency Requirement - The primary requirement for the DMS terminal processor programs is that the functional modules provide an extremely high degree of processing efficiency. This is an absolute necessity for the DMS to provide short response times to the many queries and update requests from the multiple terminal users.

- Interpretive Processing - The terminal processor itself must be able to perform the operations requested by the multiple terminal users. This capability eliminates the tremendous amount of lost time and inefficiency which result when a terminal processor must create, generate, and then execute temporary programs which perform the operations requested by users.

  The terminal processor itself should contain pre-stored functional modules which, when invoked by the terminal user entries, perform the requested user operations. This capability is called interpretive Processing (see Figure I-1).

- Macro Terminal Processor Language - The terminal processor program routines must also be easy to modify and expand. A high level language, although easy to modify and expand, normally provides slightly less processing efficiency, and therefore should not be used for the terminal processor pre-stored program routines. Instead, assembly language programs containing many well defined macros should be used. A macro is simply a series of assembly language program instructions that perform a specific processing function. Since macro structures can be standardized and repeated many times throughout program routines, program modification and expansion is greatly simplified. If it becomes necessary to transfer the DMS to a new computer, only the assembly language portions of the terminal processor would have to be rewritten. If processing efficiency is not the most critical item in the terminal processor, then it should be written in a high level language.

I.3 GENERATED USER PROGRAMS

- High Level User Program Language - Only the Batch Processor should generate user application programs that will perform the user requested functions. These generated user application programs must be easy to modify and expand by the Batch Processor user. The user programs generated by the Batch Processor should, therefore, be written in a high level language, such as COBOL. This would allow the Batch Processor user to easily modify and expand his programs at two different levels: at the DMS functional language level, and the user application program language level.

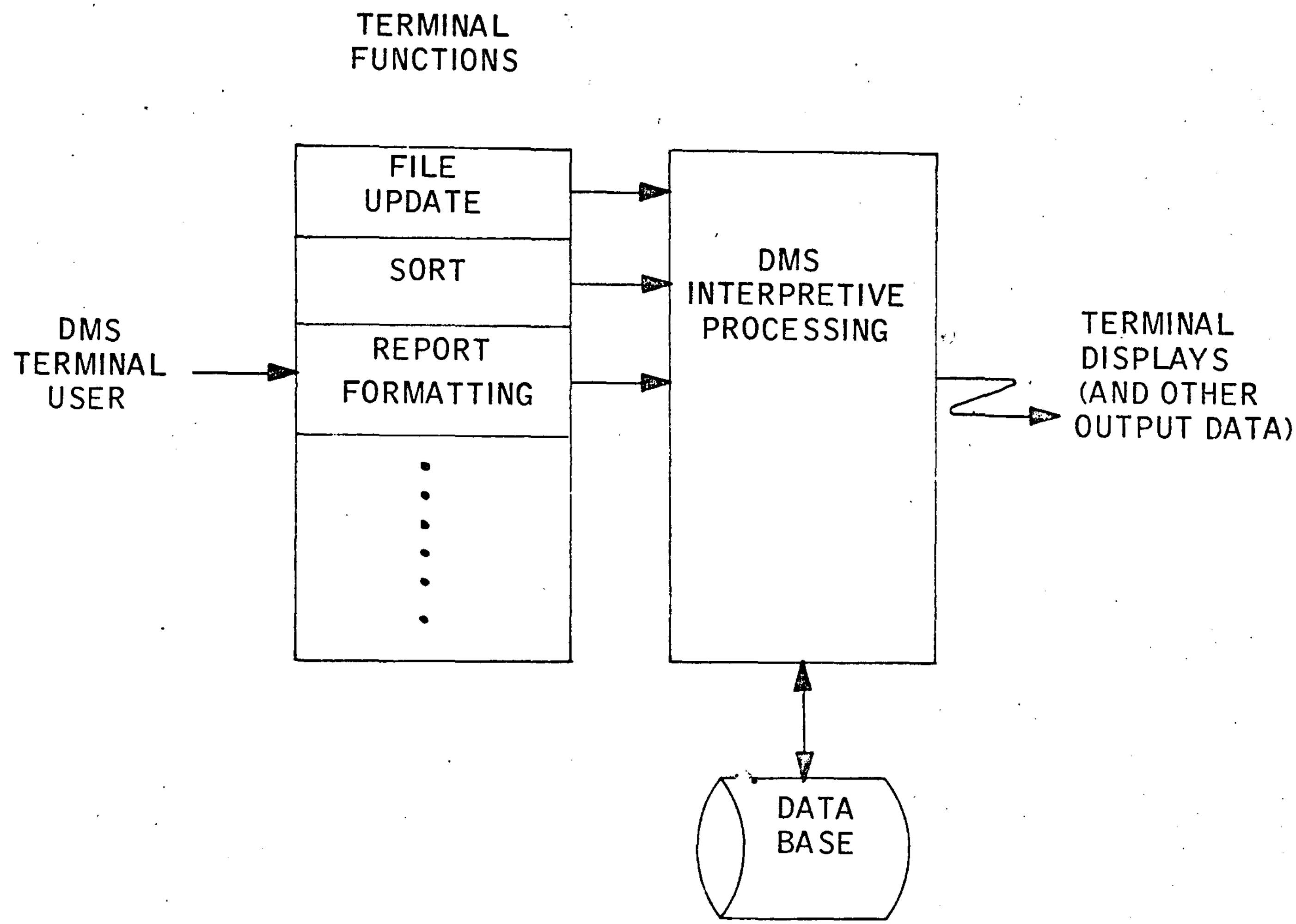


Figure I-1. DMS Terminal Processing

CSC

APPENDIX J - NEW DATA BASE STORAGE HARDWARE

APPENDIX J - NEW DATA BASE STORAGE HARDWARE

The principal data base problem for MSC will be determining which applications data files should be structured into the center-wide data base. The main controlling factor will be, of course, the amount of on-line data storage available for the MSC data base. The type of hardware utilized for the data base storage will decide, to a large extent, the volume of MSC data that can be structured into the data base.

There have been two new recent innovations in utilizing computer hardware other than disks or drums for on-line data base storage. The two new hardware data storage hardware system designs are provided by the Terrabit Memory System (of the AMPEX Corporation) and the ILLIAC IV System (of the Burroughs Corporation).

J.1 TERRABIT MEMORY SYSTEM (TBM)

Up to 400 billion data bytes can be stored on-line for rapid access by terminal users. This data storage is equivalent to the data storage provided by 1500 IBM 2314 disk drives. The TBM system utilizes standard two inch wide video tape. The data is recorded in blocks on the tape, each block being identified by a unique address. Each TBM reel can contain 5.5 billion data bytes, which is equivalent to 500 computer tapes.

Rapid access to any records on the tapes is achieved by searching the record block identifiers at tape speeds of one-thousand (1000) inches per second, forward and backward. This high tape search speed together with high data packing density and six simultaneous tape accesses make possible the searching of the equivalent of sixty (60) conventional full computer tapes in one second.

There are also other technical features of the TBM. There is extensive built-in file protection and data security. TBM is modular; it is expandable in 11 billion byte increments. There can be six simultaneous data transfers and searches. There is dynamic device reconfiguration and multipath access. System control and hardware fault diagnosis and isolation is also provided by internal computers. Read/write error detection and correction logic is provided. Update in place and selective block (record) erase are other important features. An internal data file to file copy is provided. Two output files can be written simultaneously. TBM can be utilized in a stand alone environment or it can be interfaced with other computers. All these features can be obtained for a cost as low as one ten-thousandth (.0001) of a cent per bit.

There are many advantages provided by the TBM system. It is an economical approach to data base consolidation into a single integrated and meaningful structure. TBM's rapid file maintenance capabilities and high throughput have, on occasion, reduced application processing time from more than five hours to a few minutes. With TBM's versatile access methods, only the desired records need be sent to the host computer for processing. A dynamic multilevel priority processing capability, together with many simultaneous random accesses to multiple data files make TBM a powerful element of on-line, real-time data communication systems. Protection against accidental overwriting is provided through

read only interlocks. Data access protection is implemented through user oriented codes associated with individual blocks or entire files. TBM provides an economical means of keeping several generations of files on-line. TBM greatly facilitates job scheduling since tapes and disk packs do not have to be retrieved and mounted - the data is always there. High reliability is achieved through extensive hardware component redundancy, multipath access and dynamic device reconfiguration.

For further information concerning TBM, the AMPEX Corporation should be contacted.

J.2 ILLIAC IV

One example of the expanding technology in the computer industry today is the ILLIAC IV computer. New techniques of memory storage, utilizing laser beams, give ILLIAC IV the capacity to store one trillion bits of information in a comparatively small space. One would need about 250,000 standard magnetic tapes to maintain an equivalent amount of data. This new memory storage is called Archival Memory. It is a new high-capacity secondary memory, developed by the Precision Instrument Company. The beam from an argon laser records binary data by burning microscopic holes in a thin film of metal coated on a strip of polyester sheet, which is carried by a rotating drum. Each data strip can store some 2.9 billion bits, the equivalent of 625 reels of standard magnetic tape in less than 1% of the volume. The "strip file" provides storage for 400 such data strips containing more than a trillion bits. The time to locate data stored on any one of the 400 strips is about five seconds. Within the same data strip data can be located in 200 miliseconds. The read-and-record rate is four million bits a second.

This machine will be capable of executing between 1000,000,000 and 200,000,000 individual commands per second. Unlike its three predecessors (ILLIAC I, II AND III) and all computers now on the market, which solve problems by a series of sequential steps, ILLIAC IV is designed to perform as many as 64 computations simultaneously. For such a computing structure to be utilized efficiently the problem must be amenable to parallel, rather than sequential, processing. In actuality, problems of this kind constitute a considerable part of the total computational spectrum, ranging from payroll calculations to linear programming to models of the general circulation of the atmosphere for use in weather prediction. For example, a typical linear-programming problem that might occupy a large present-generation computer for six to eight hours should be solvable by ILLIAC IV in less than two minutes, a time reduction of at least 200 to 1. These problems could present over 4,000 constraints (the defined conditions or parameters of the situation) and 10,000 variables.

The key factor in facilitating the handling of the problem, of course, is solving many parts of the problem at the same time - up to 64 simultaneous computations on 64 "slave" or auxiliary processing units - rather than only solving one part of the problem at a time.

The ultimate limitation of the operating speed of a computer designed to operate sequentially is the speed with which a signal can be propagated through an electrical conductor. In practice this is somewhat less than the speed of light, which takes one nanosecond (one billionth of a second) to travel about one foot. Although integrated circuits containing

transistors packed together with a density ranging from several hundred to several thousand per square inch have helped greatly to reduce the length of interconnections inside computers, designers have been increasingly aware that new kinds of logical organization are needed to penetrate the barrier set by the speed of light. ILLIAC IV circumvents this problem by parallel processing.

ILLIAC IV can diagnose its own problems. In a system containing more than six million components one can expect a component or a connection to fail every few hours. For this reason much attention has been devoted to testing and diagnostic procedures. Each of the 64 processing units will be subjected regularly to an extensive library of automatic tests. If a unit should fail one of these tests, it can be quickly unplugged and replaced by a spare, with only a brief loss of operating time. When the defective unit has been taken out of service, the precise cause of the failure will be determined by a separate diagnostic computer. Once the fault has been found and repaired, the unit will be returned to the inventory of spares.

It took two medium sized computers working almost full time for two years to help design the meticulous micro-circuitry of the hardware and prepare diagnostic programs for the software. Another computer is wholly devoted to talking to ILLIAC IV. "Noboby" else can. This general purpose computer is responsible for translating the many languages of the computer programmers into the hardware-determined language of the big machine itself.

CSC

APPENDIX K - GLOSSARY OF TERMS

APPENDIX K - GLOSSARY OF TERMS

K.1 ACCESS KEY

The sequencing item or record key that determines the placement of each record in the data file. The access key is used when reading or writing any record in the file.

K.2 ACCESS TIME

The time interval between the instant at which data is requested to be read or written and the instant the device actually begins the data transfer operation.

K.3 ANSWER SET

Records which are created as the result of terminal user selection criteria in queries. These records are then displayed to the terminal user.

K.4 APPLICATION PROGRAM

A computer program which performs one or more basic functions such as file update, report generation, data editing, sorting, etc.

K.5 APPLICATION SYSTEM

Application programs combined into a logical series or organization of processing steps to provide a major functional processing system. An application system normally contains a series of programs to edit input data, update data files, extract data from data files, and generate reports.

K.6 AUDIT TRAIL

The saving of all modifications made to data in the data base. It could include the saving of the updated data base records before and after modifications are made.

K.7 BATCH PROCESSING

The scheduling and processing of applications that do not require real-time or immediate computer processing. Normally applications which do not require quick answers or which process a large amount of input data are run as batch jobs.

K.8 CENTRAL PROCESSING UNIT (CPU)

The computer hardware unit in which the actual execution and processing of computer programs takes place.

K.9 CRT

The abbreviation for cathode ray tube. A CRT is used in many terminal devices for displaying user specified data items.

K.10 DATA

Items of information.

K.11 DATA BASE

A collection of one or more data files.

K.12 DATA ITEM (FIELD)

A piece of information in a data file. Normally this is the smallest organization of data in a data file.

K.13 DATA MANAGEMENT SUPERVISOR

A set of interrelated computer programs which provide capabilities such as data description, creation, maintenance, sorting, retrieval and reporting.

K.14 DATA RECORD

A logical organization of related data items which describe a particular activity such as procurement. A data file consists of a series of data records.

K.15 DATA RETRIEVAL

The reading of data records from the data base into the computer's core storage for processing. Data is normally retrieved based upon conditions specified by a user's query.

K.16 DATA SECURITY

Data protection provided by the DMS to prevent unauthorized read/write operations on sensitive or classified data.

K.17 DATA SET (DATA FILE)

A series of data records containing information concerning a particular application of activity. A payroll data set is a collection of individual employee payroll records.

K.18 DATA STRUCTURING

The physical arrangement of data so that it can be identified, created, updated, and retrieved.

K.19 DATA VALIDATION

The checking of data items against specifications to ensure the data is acceptable. If an item does not meet the specifications, it is rejected.

K.20 DIAGNOSTIC

A meaningful, reported comment regarding a problem that was encountered during processing.

K.21 DIRECT ACCESS STORAGE DEVICE (DASD)

A hardware device such as magnetic disk and drum which allow any data record to be directly accessed. It can be contrasted with the hardware devices such as tape which permit only sequential searches for data records.

K.22 DMS CAPABILITIES

The functional operations provided to users by a DMS. This includes functions such as data editing and updating, sorting, report formatting and report generation.

K.23 DYNAMIC DATA FILE

A data file whose volume (number of records) is constantly increasing.

K.24 FILE CREATION

The initial writing of a series of data records to form a data file.

K.25 FUNCTIONAL MODULES

Program logic modules which perform functional operations such as file description, file creation and maintenance, sorting, retrieving, report formatting and generation.

K.26 HARDWARE

The computer with all its functional units and devices, such as central processing units, terminals, tape drives, core storage, printer, etc.

K.27 KEYWORD

Keywords associate data records in a file with particular subjects or categories. Keywords are used for searching a data file for documents related to a particular subject, category, author, etc.

K.28 LANGUAGE

A means by which a user communicates with the DMS and the computer. A terminal user language and a batch processing language are provided by the DMS.

K.29 MULTIPLE FILE ACCESS

The capability to retrieve data from many data files in the same query.

K.30 MULTIPLE FILE UPDATE

The capability to automatically update a data item in all files in which it exists whenever an update of the item occurs in any file.

K.31 OPERATING SYSTEM

The resident computer system which actually performs the basic functions of hardware device input/output (as directed by the DMS or application program) and coordinates the execution of the programs in the central processing unit.

K.32 QUERY

The retrieval of data from the data base that satisfies the terminal user's specified search criteria. The retrieval data is then normally displayed on a terminal CRT and/or printed on a hard copy device.

K.33 REAL-TIME PROCESSING

The immediate processing of input data and user requests at the time they are received. This capability provided by a DMS allows terminal users to rapidly query and update data in the data base.

K.34 REPORT FORMATTING

The arranging and editing of data items that will be displayed on a terminal CRT or printed in a hard copy report.

K.35 RESPONSE TIME

The time interval between the start of a terminal functional operation and the actual completion of the operation or when the specified data is made available at the terminal.

K.36 RUN

The execution and processing of one or more computer programs.

K.37 SEARCH

To examine records of a file or data item within records for desired values of specified conditions.

K.38 SOFTWARE

The combination of the computer's operating system, DMS, and application programs working jointly to perform the desired functional data processing tasks.

K.39 SORT

The sequencing of the records in a data file by using specified data items to control the placement of records in the file.

K.40 STANDARDIZED PROGRAM ROUTINE

Program modules that for any particular functional operation contain the same basic processing logic. The only processing differences in these routines result from user specified parameters.

K.41 STATIC DATA FILE

A data file whose volume (number of records) remains approximately the same.

K.42 SYNONYM

Another data name that can be used in referencing a particular data item.

K.43 TERMINAL

A hardware device used for real-time querying and update of data in the data base.

K.44 TERMINAL PROCESSING

The querying and update of data in the data base as specified by a terminal user.

K.45 VARIABLE LENGTH DATA

Data items which can vary in length within the records of a file. Some examples are narrative data, comments and descriptions, etc.

K.46 VECTOR GENERATION

The capability of a terminal device to generate vertical, horizontal, and diagonal lines for drawings, graphs and models.